FIG. 1

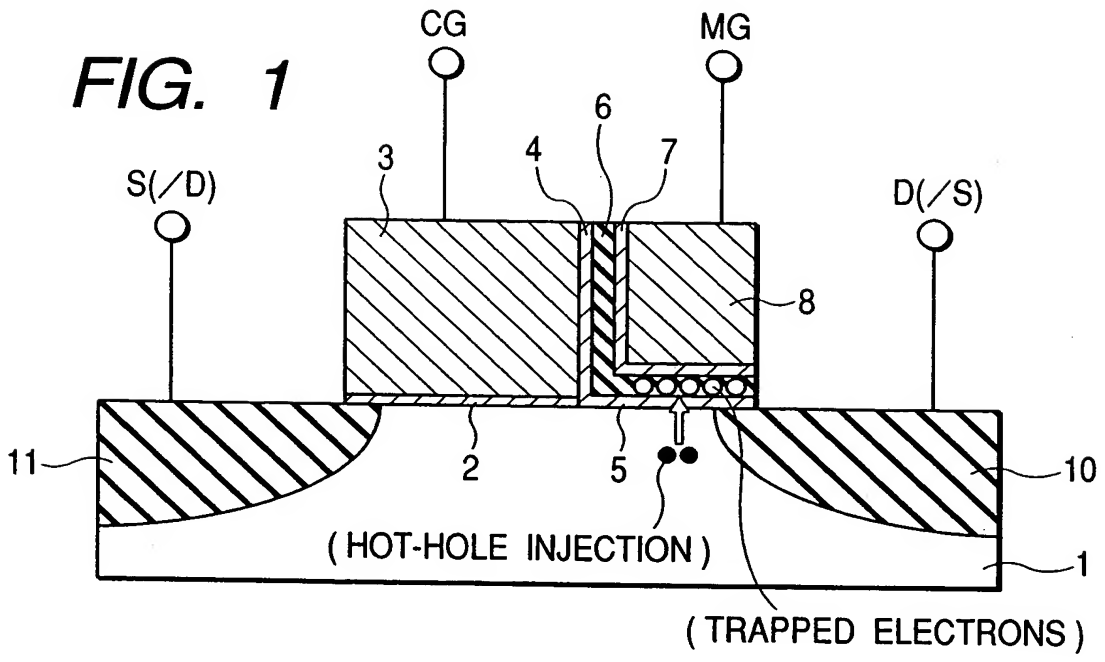

CG
MG
S(/D)
D(/S)
3
4
6
7
8
11
2
5
10
(HOT-HOLE INJECTION)
1
(TRAPPED ELECTRONS)

FIG. 2

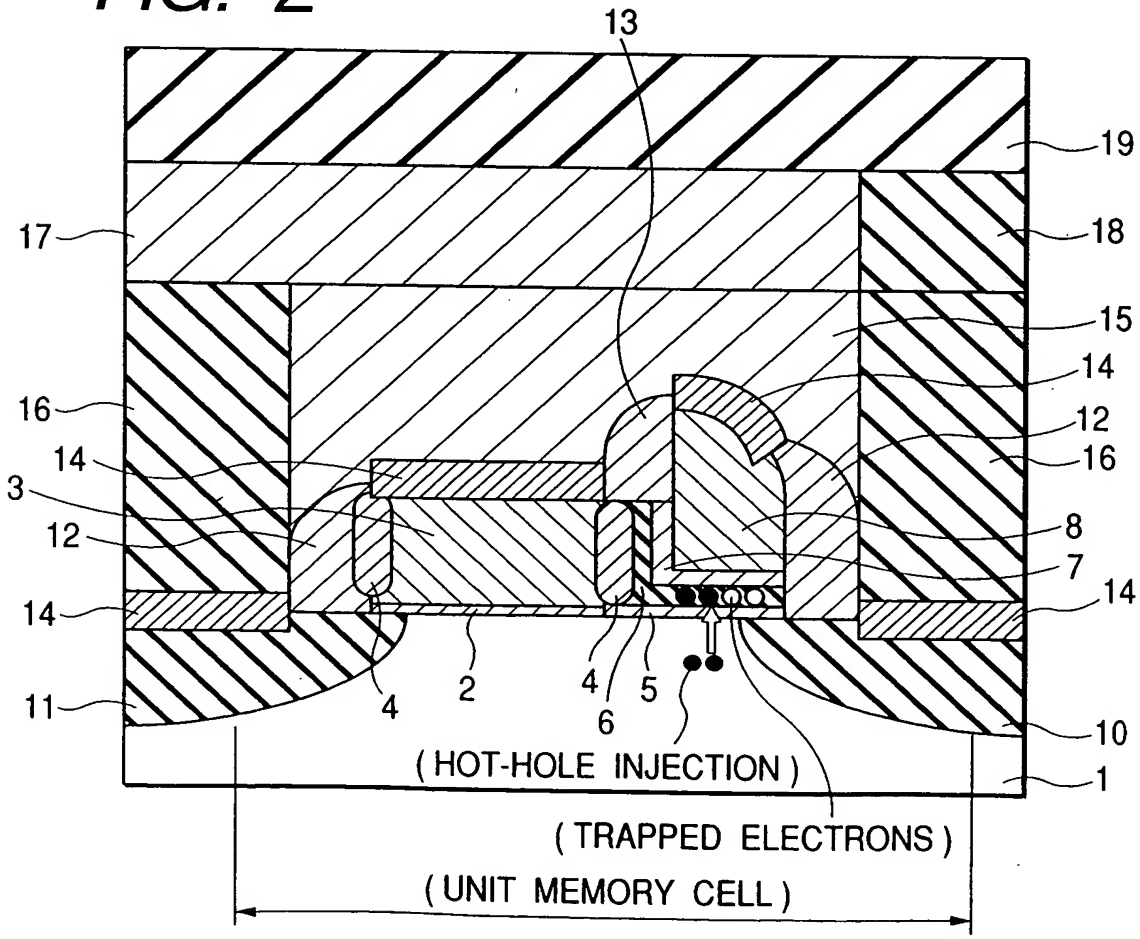

13
19
17
18
15
14
16
12
16
14
3
12
8
7
14
14
11
4
2
4
5
6
10
(HOT-HOLE INJECTION)
1
(TRAPPED ELECTRONS)
(UNIT MEMORY CELL)

FIG. 3

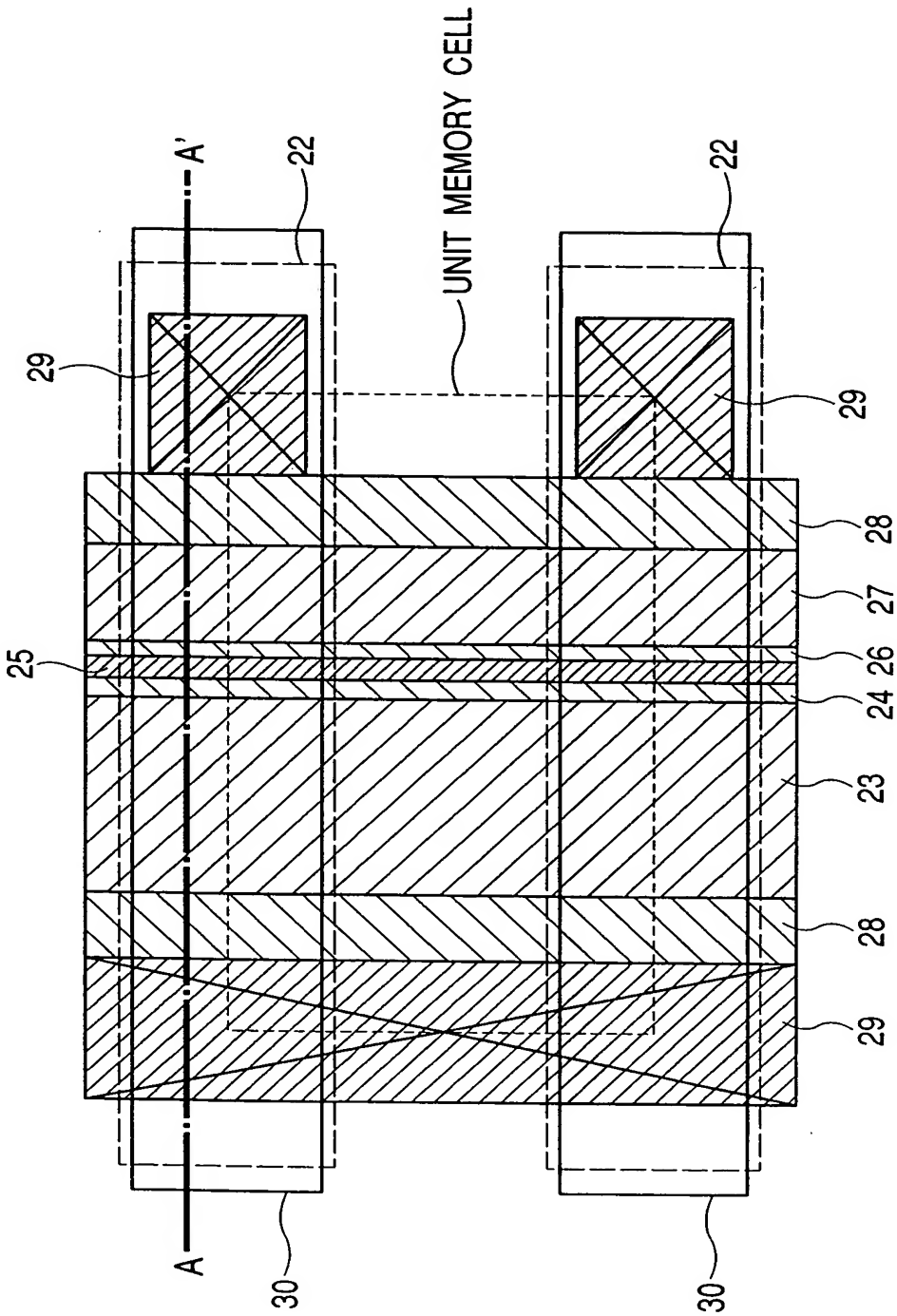


FIG. 4

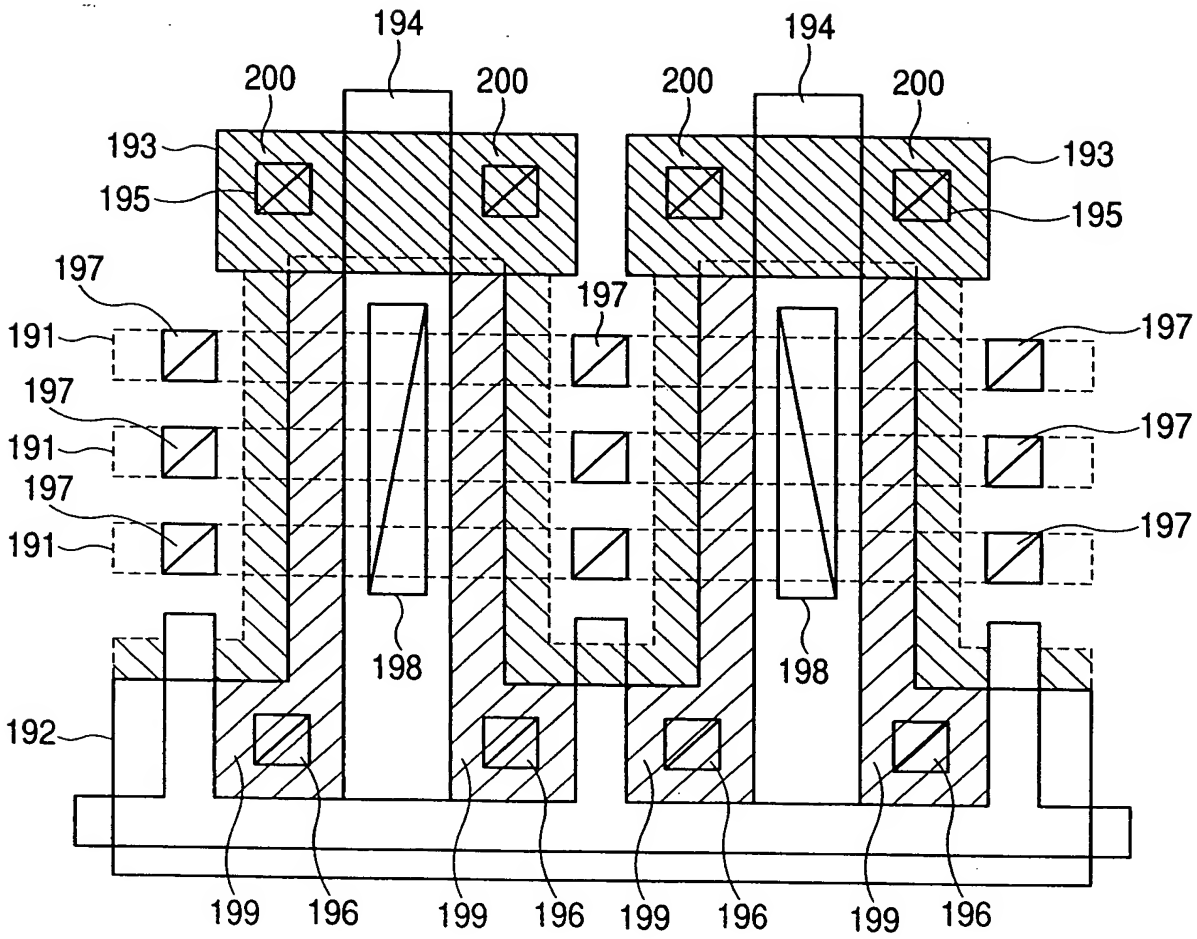

194
194
200
200
200
200
193
193
195
195
197
197
197
191
191
197
191
197
197
197
198
198
192
199
196
199
196
199
196
199
196

FIG. 5

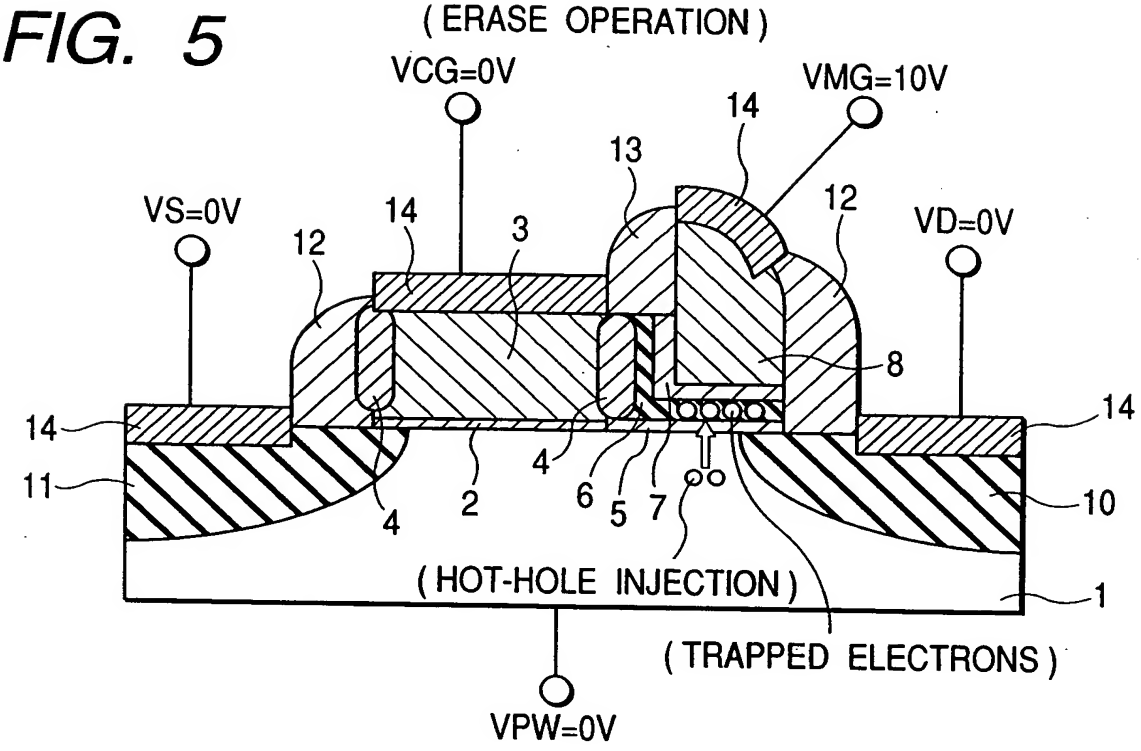

(ERASE OPERATION)
VCG=0V
VMG=10V
VS=0V
VD=0V
14
13
12
3
8
11
2
4
6
5
7
10
1
(HOT-HOLE INJECTION)
(TRAPPED ELECTRONS)
VPW=0V

FIG. 6

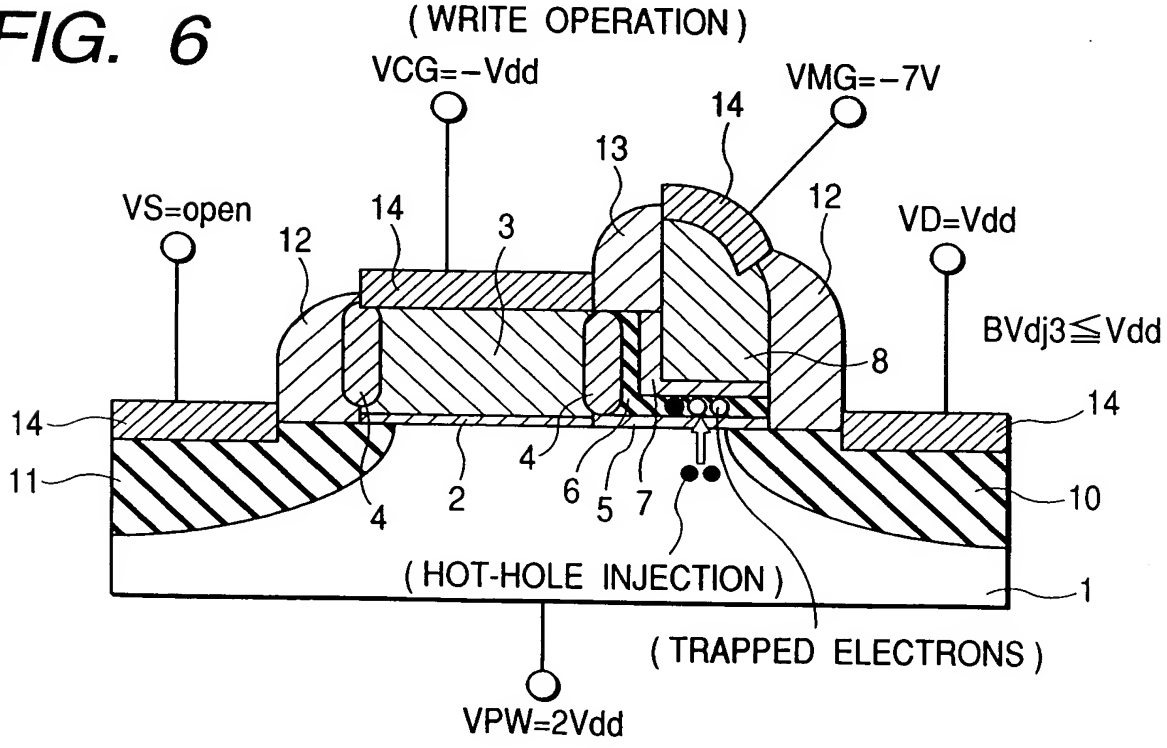

(WRITE OPERATION)
VCG=−Vdd
VMG=−7V
VS=open
VD=Vdd
BVdj3≦Vdd
14
13
12
3
8
11
2
4
6
5
7
10
1
(HOT-HOLE INJECTION)
(TRAPPED ELECTRONS)
VPW=2Vdd

FIG. 7

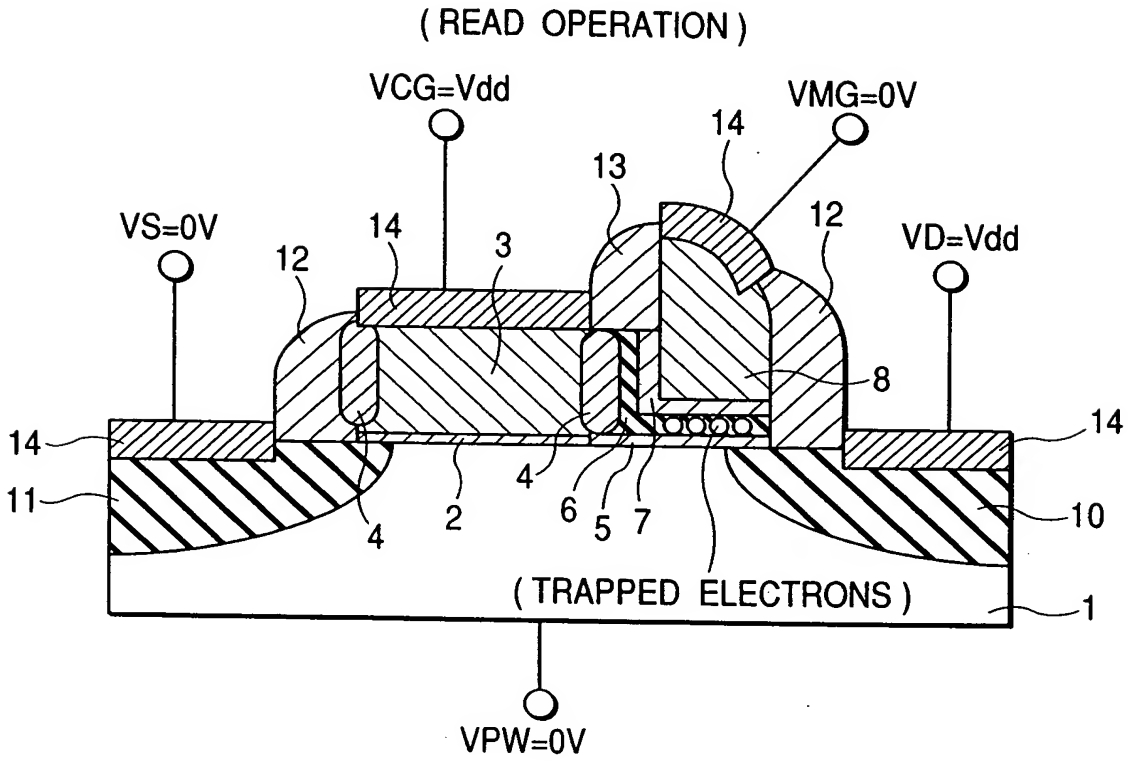

(READ OPERATION)
VCG=Vdd
VMG=0V
VS=0V
VD=Vdd
14
13
12
3
8
11
2
4
6
5
7
10
(TRAPPED ELECTRONS)
1
VPW=0V

FIG. 8

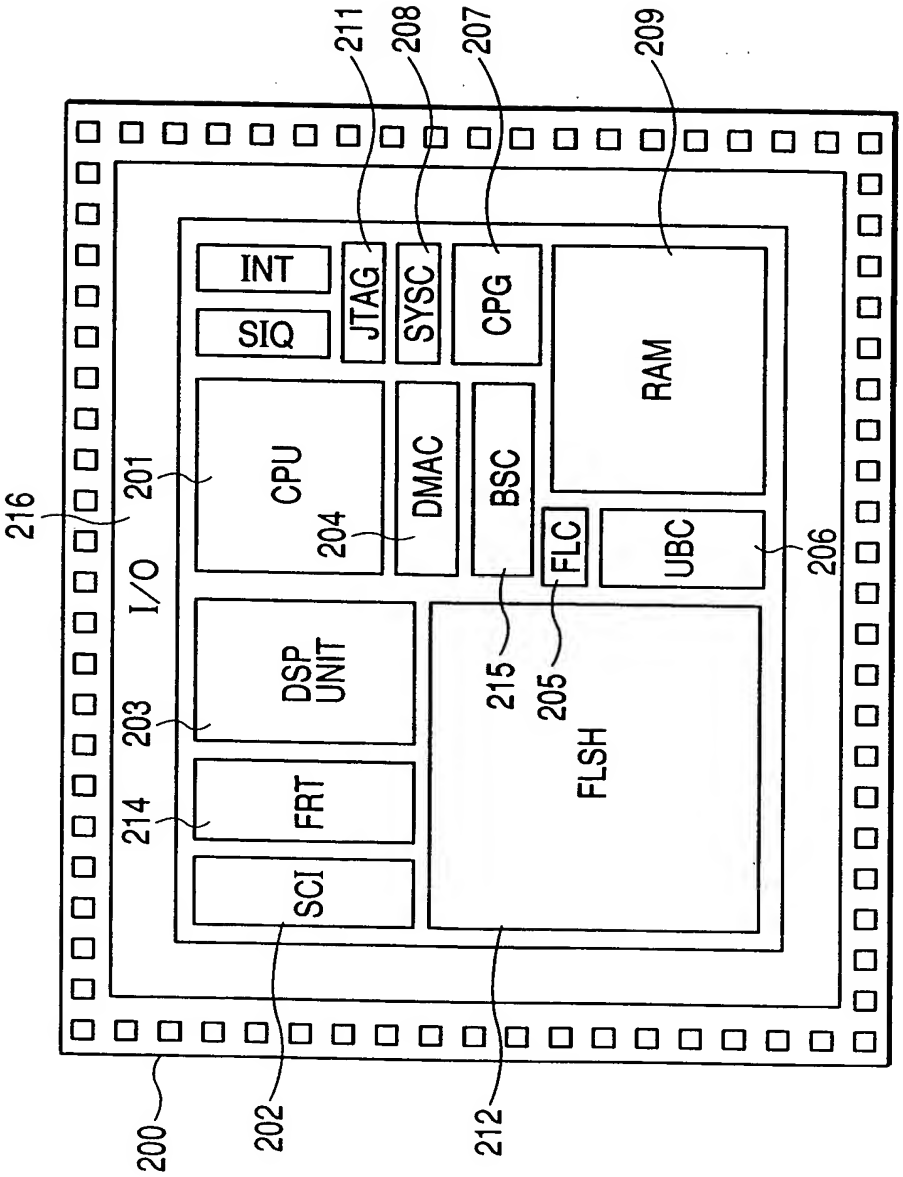

211
208
207
209
INT
SIQ
JTAG
SYSC
CPG
RAM
216
201
CPU
204
DMAC
BSC
FLC
UBC
206
I/O
DSP UNIT
203
215
205
FLSH
214
FRT
SCI
200
202
212

FIG. 9

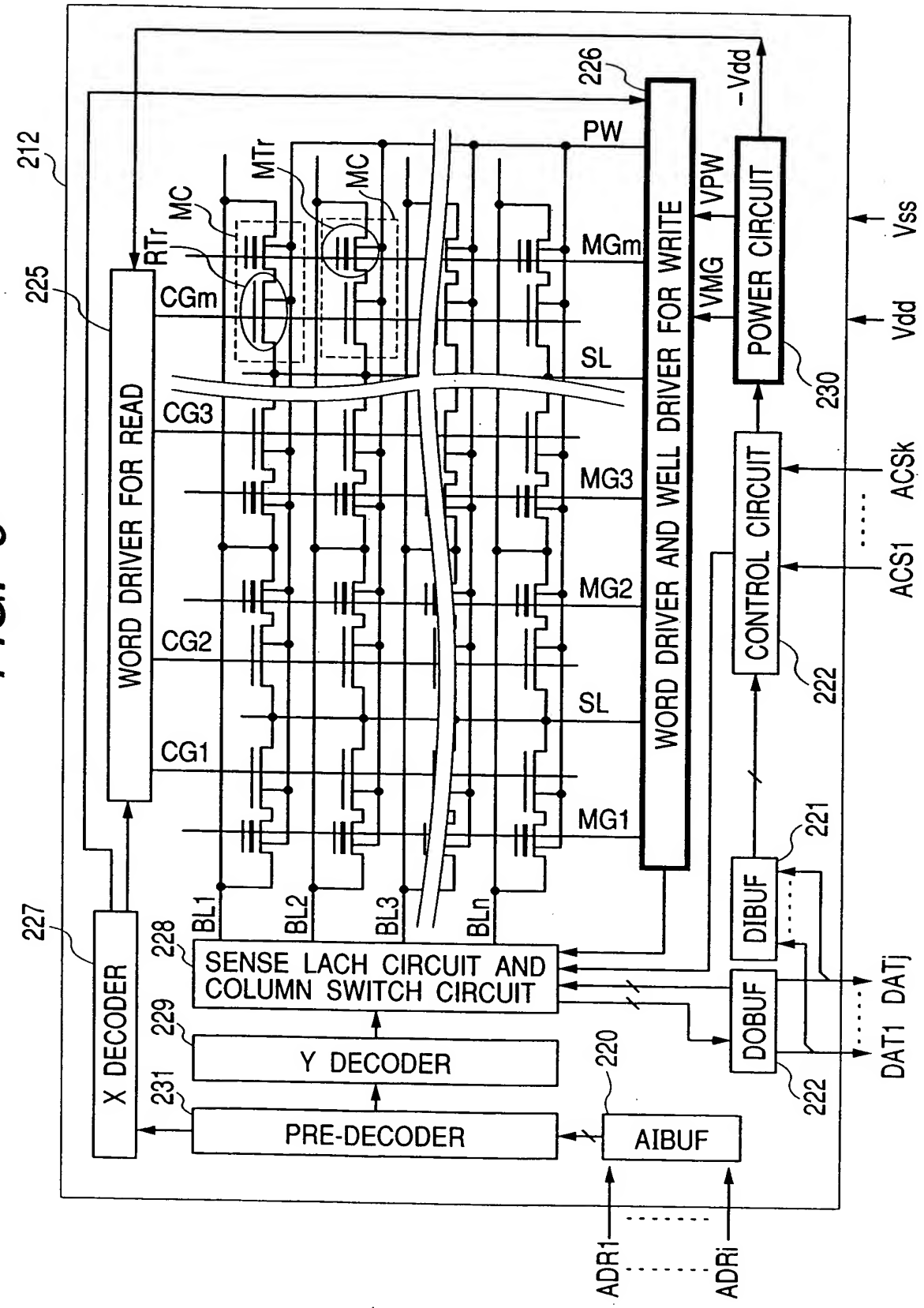

212
225
226
227
228
229
230
231
220
221
222
WORD DRIVER FOR READ
WORD DRIVER AND WELL DRIVER FOR WRITE
POWER CIRCUIT
CONTROL CIRCUIT
SENSE LACH CIRCUIT AND COLUMN SWITCH CIRCUIT
Y DECODER
PRE-DECODER
X DECODER
AIBUF
DIBUF
DOBUF
PW
MGm
SL
CG3
MG3
MG2
CG2
SL
CG1
MG1
MTr
MC
RTr
CGm
BL1
BL2
BL3
BLn
-Vdd
VPW
VMG
Vss
Vdd
ACSk
ACS1
DAT1
DATj
ADR1
ADRi

FIG. 10

(ERASE OPERATION)

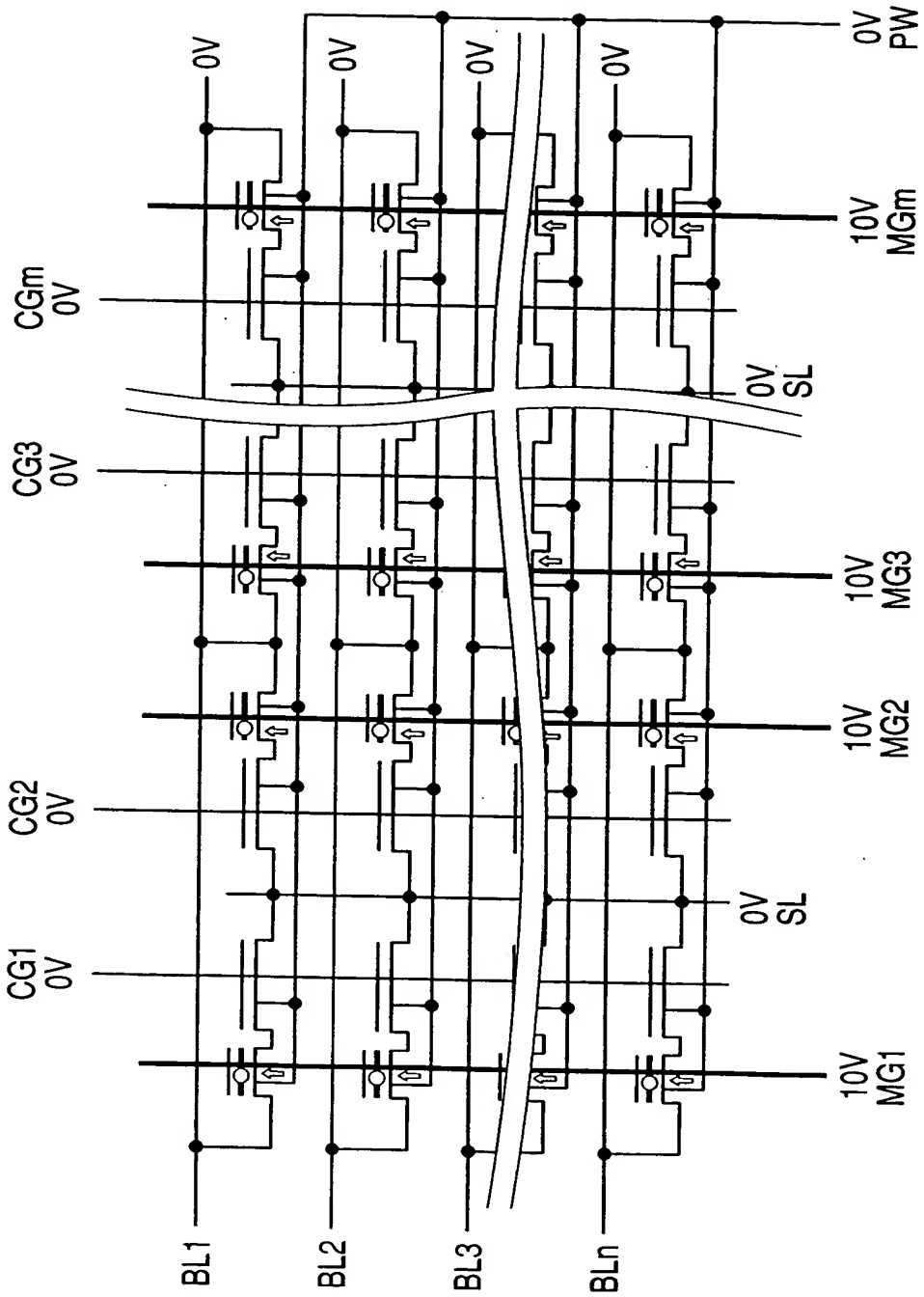


FIG. 11

(WRITE OPERATION)

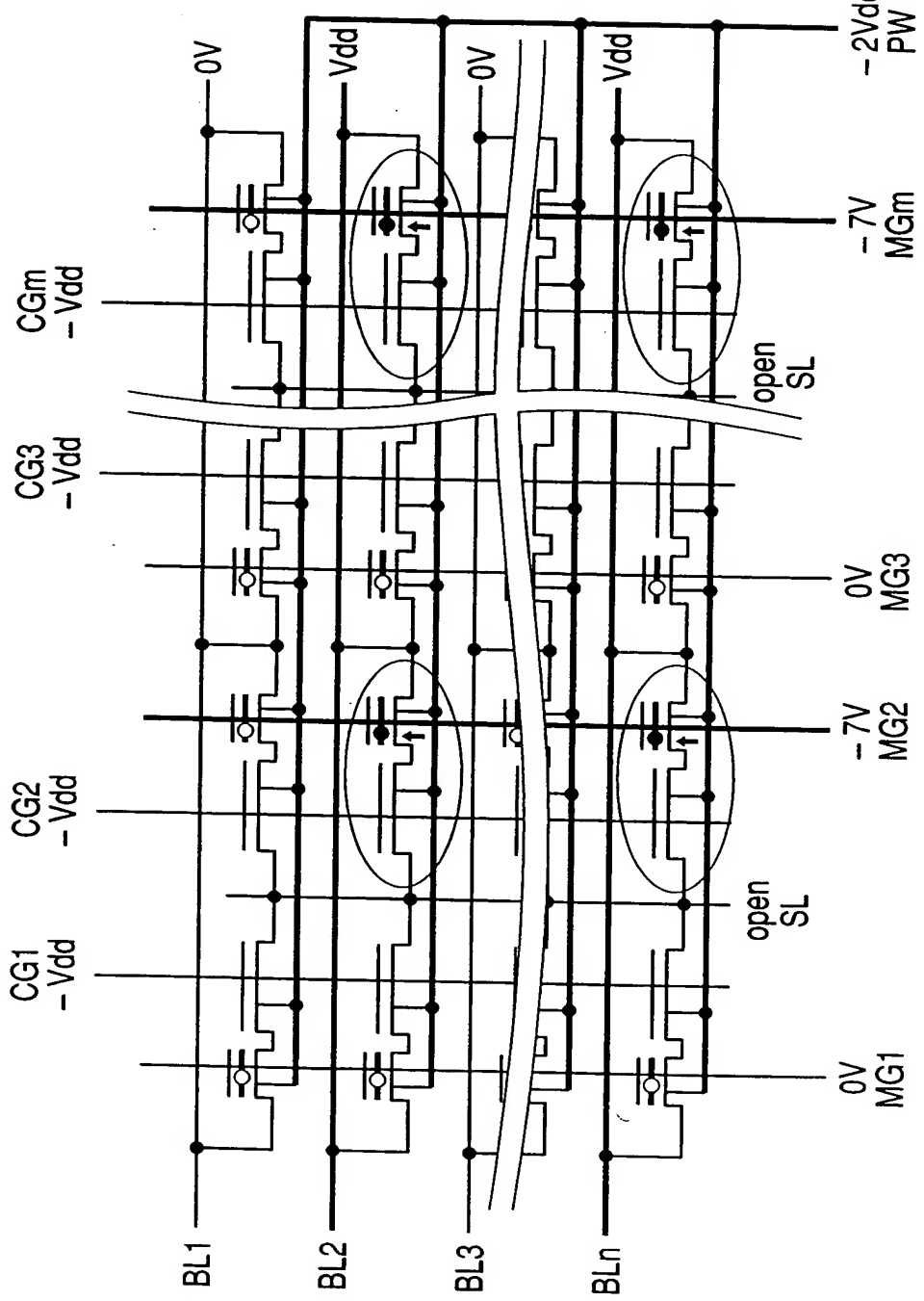


FIG. 12

(READ OPERATION)

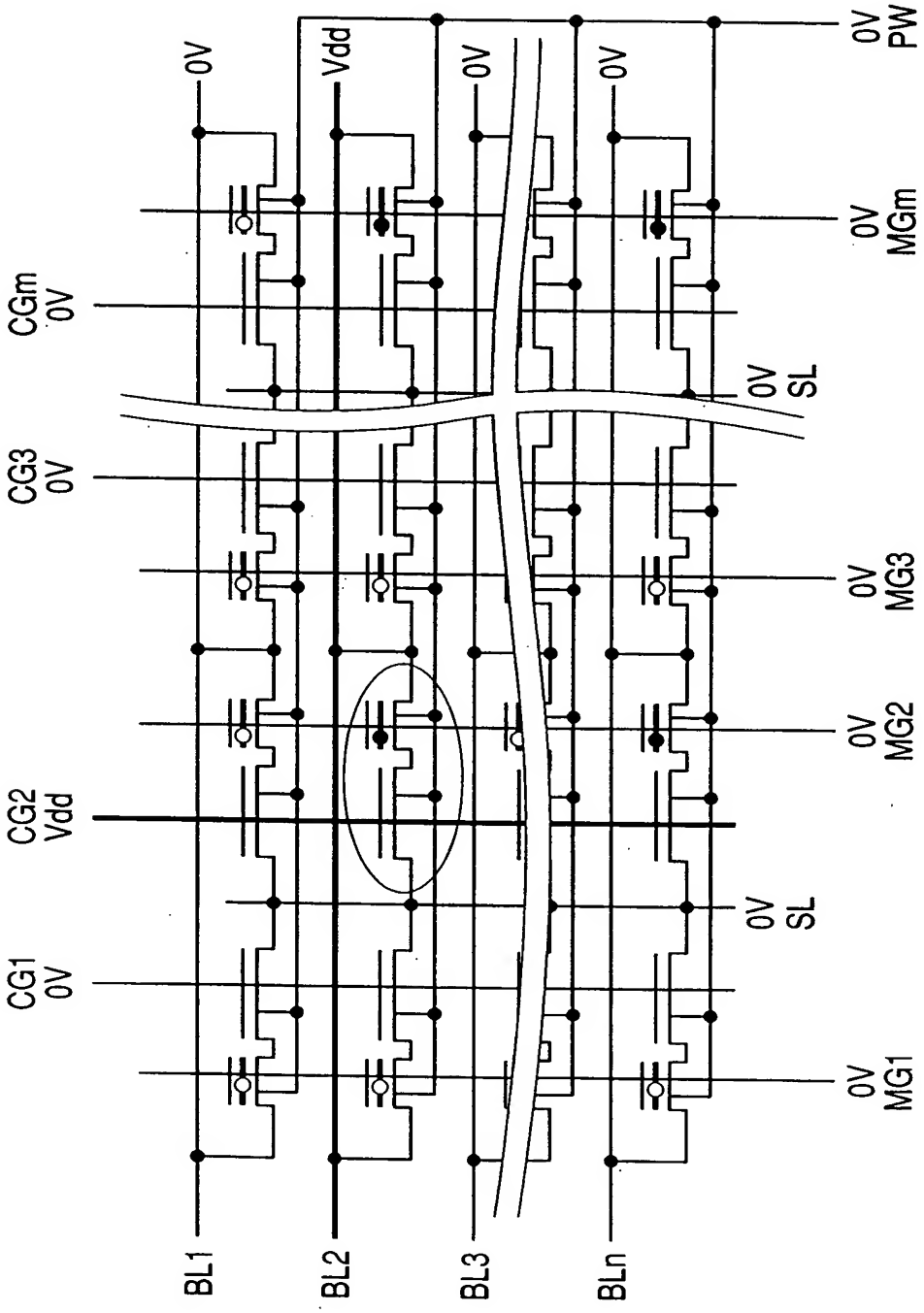


FIG. 13

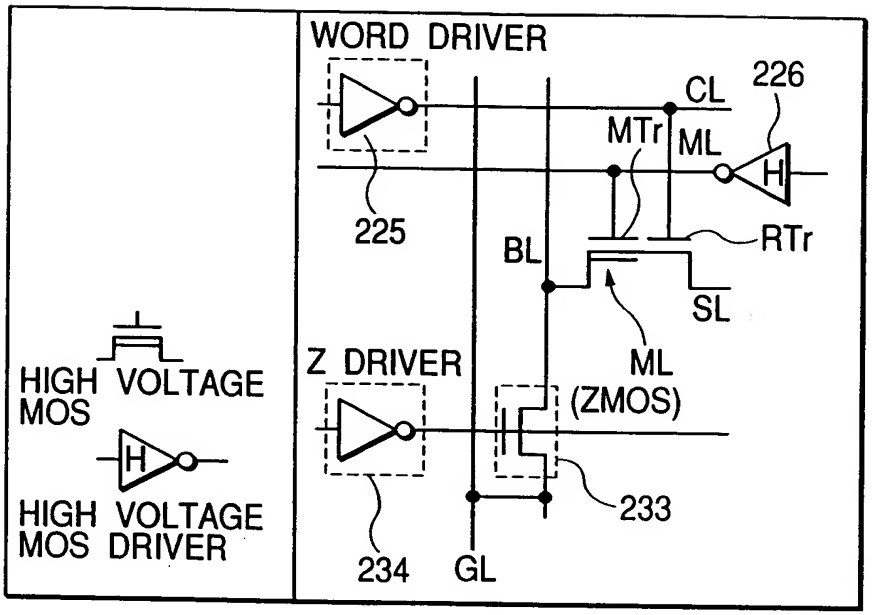

WORD DRIVER
CL
226
MTr
ML
H
225
BL
RTr
SL
ML
(ZMOS)
Z DRIVER
233
234
GL
HIGH VOLTAGE MOS
H
HIGH VOLTAGE MOS DRIVER

FIG. 14

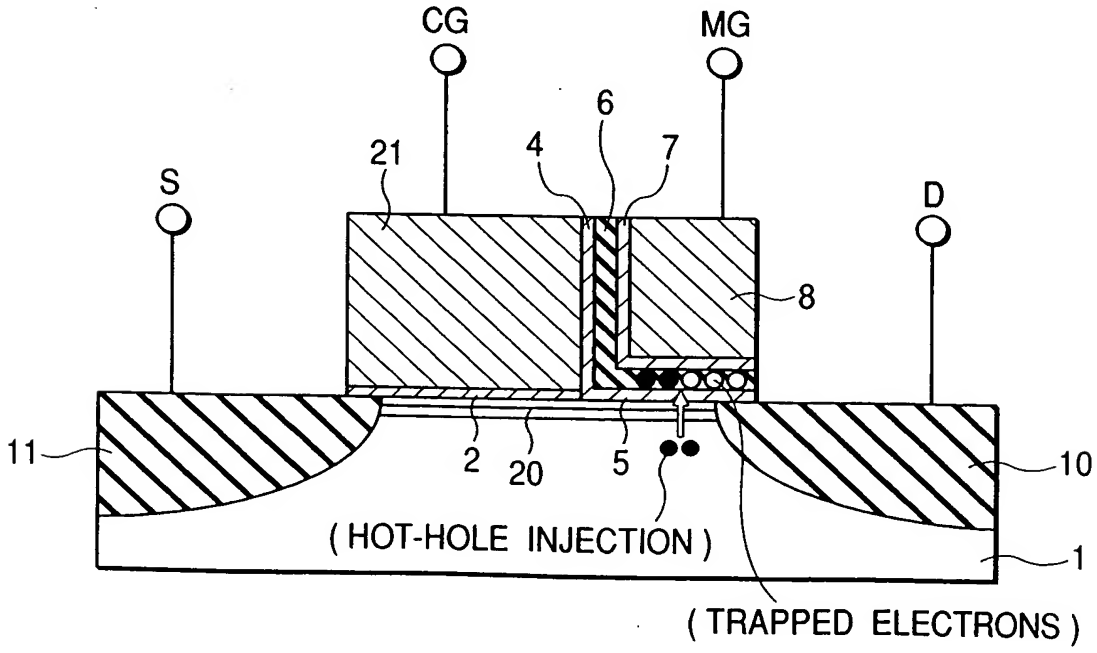

CG
MG
6
21
4
7
S
D
8
11
2
20
5
10
(HOT-HOLE INJECTION)
1
(TRAPPED ELECTRONS)

FIG. 15

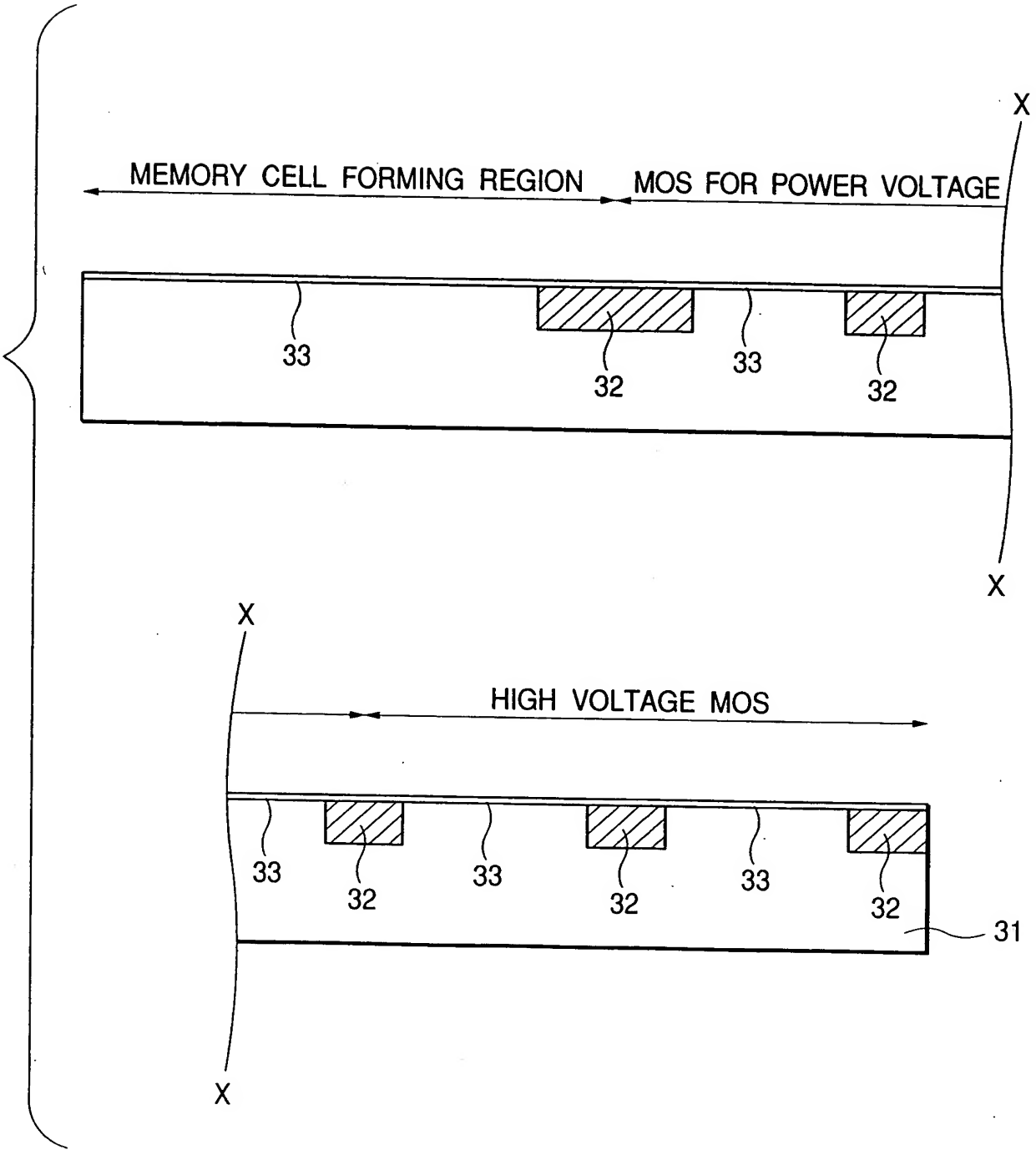

X
MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
33
32
33
32
X
X
HIGH VOLTAGE MOS
33
32
33
32
33
32
31
X

FIG. 16

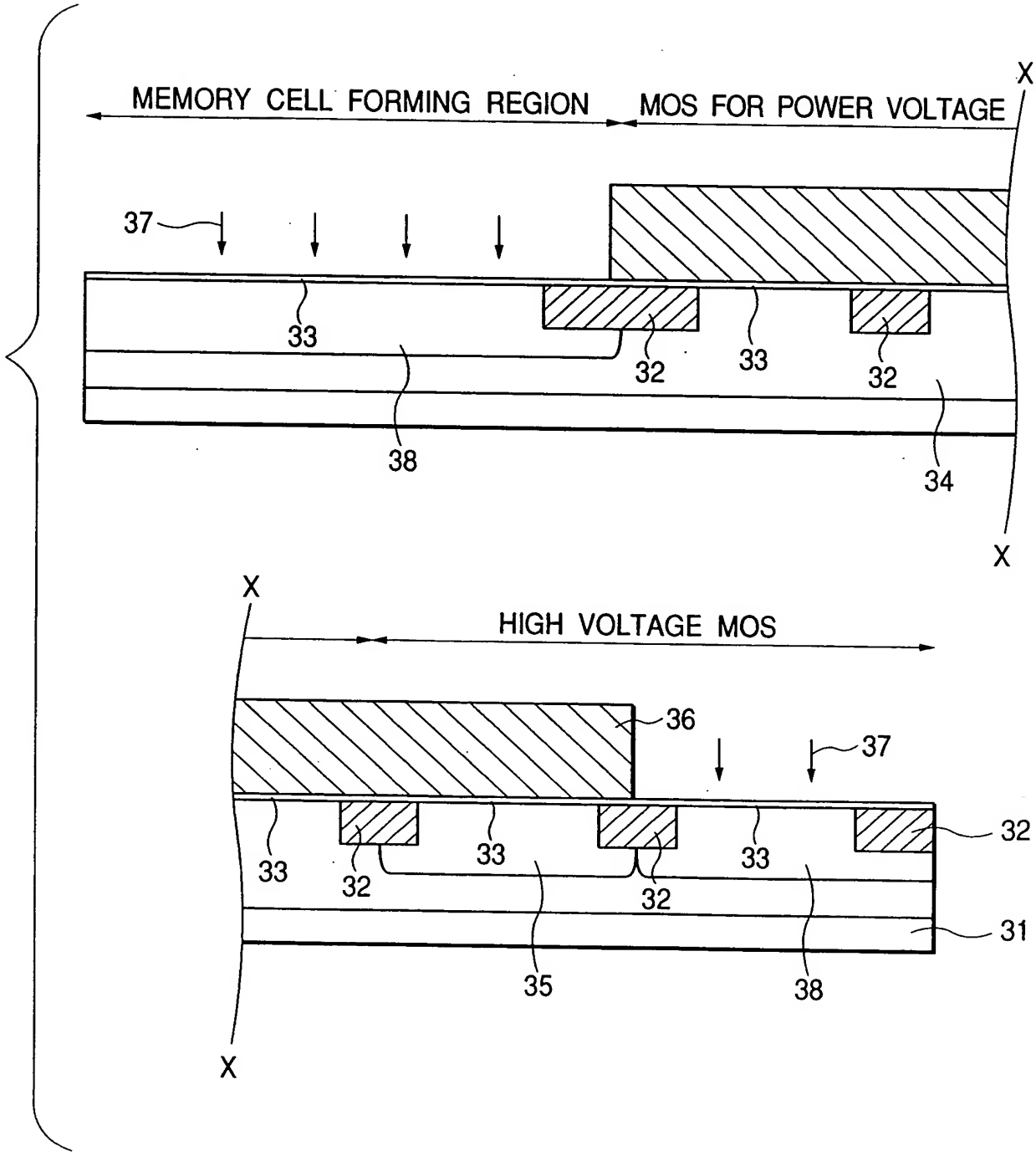

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
37
33
32
33
32
38
34
X
X
HIGH VOLTAGE MOS
36
37
32
33
33
33
32
32
31
35
38
X

FIG. 17

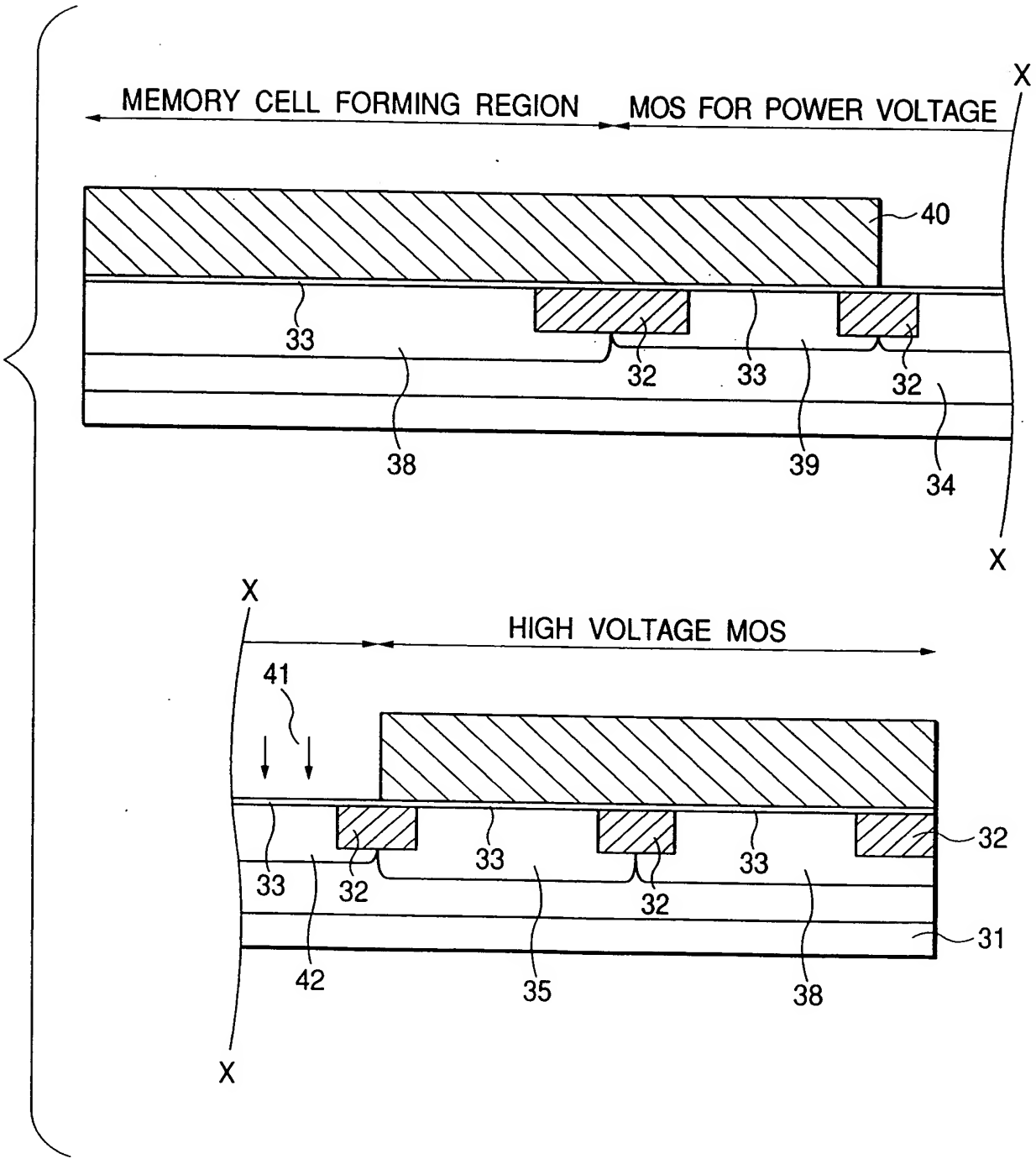

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
40
33
32
33
32
38
39
34
X
X
HIGH VOLTAGE MOS
41
33
32
33
33
32
32
31
42
35
38
X

FIG. 18

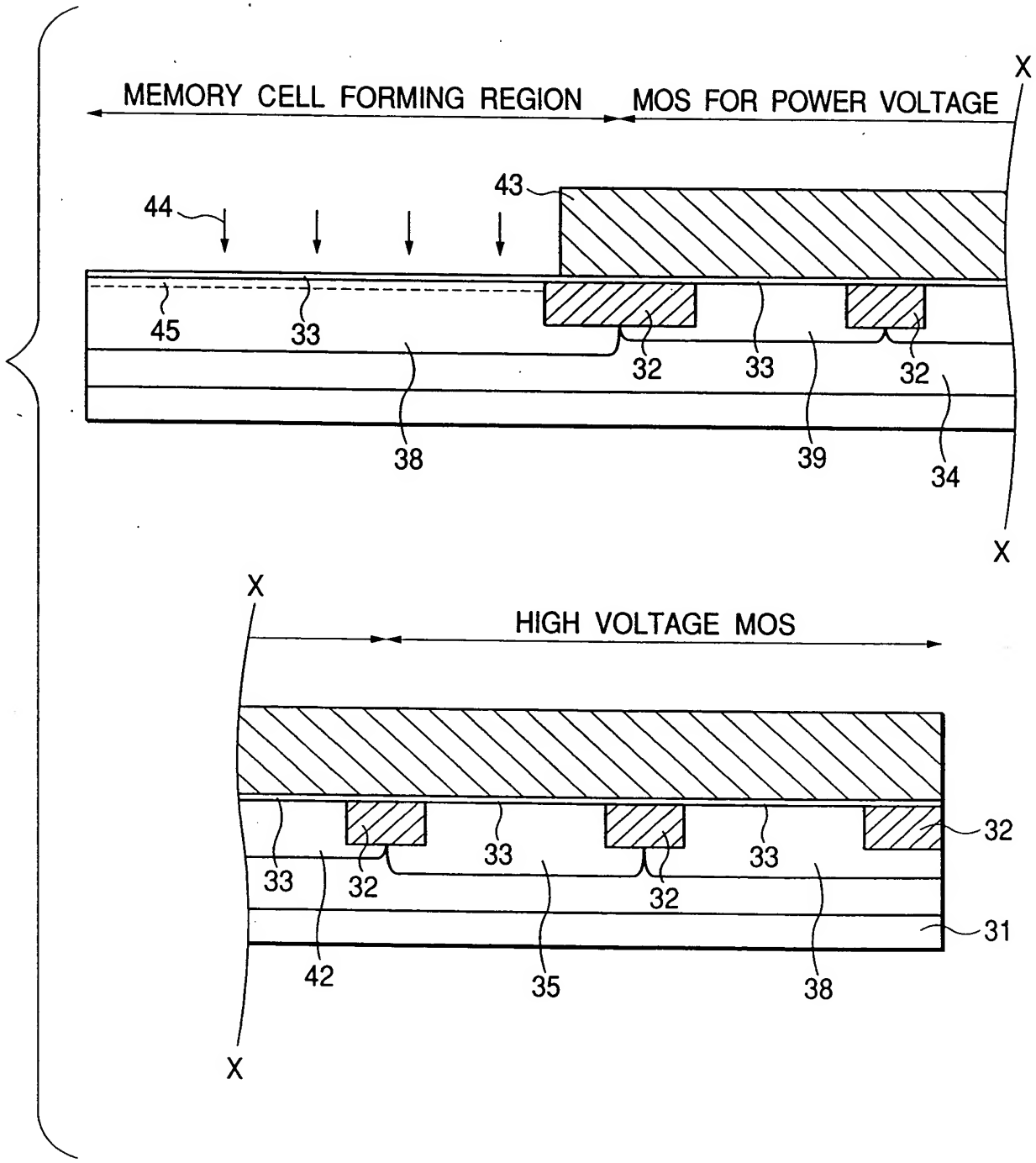

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
43
44
45
33
32
33
32
38
39
34
X
X
HIGH VOLTAGE MOS
32
33
33
33
32
32
31
42
35
38
X

FIG. 19

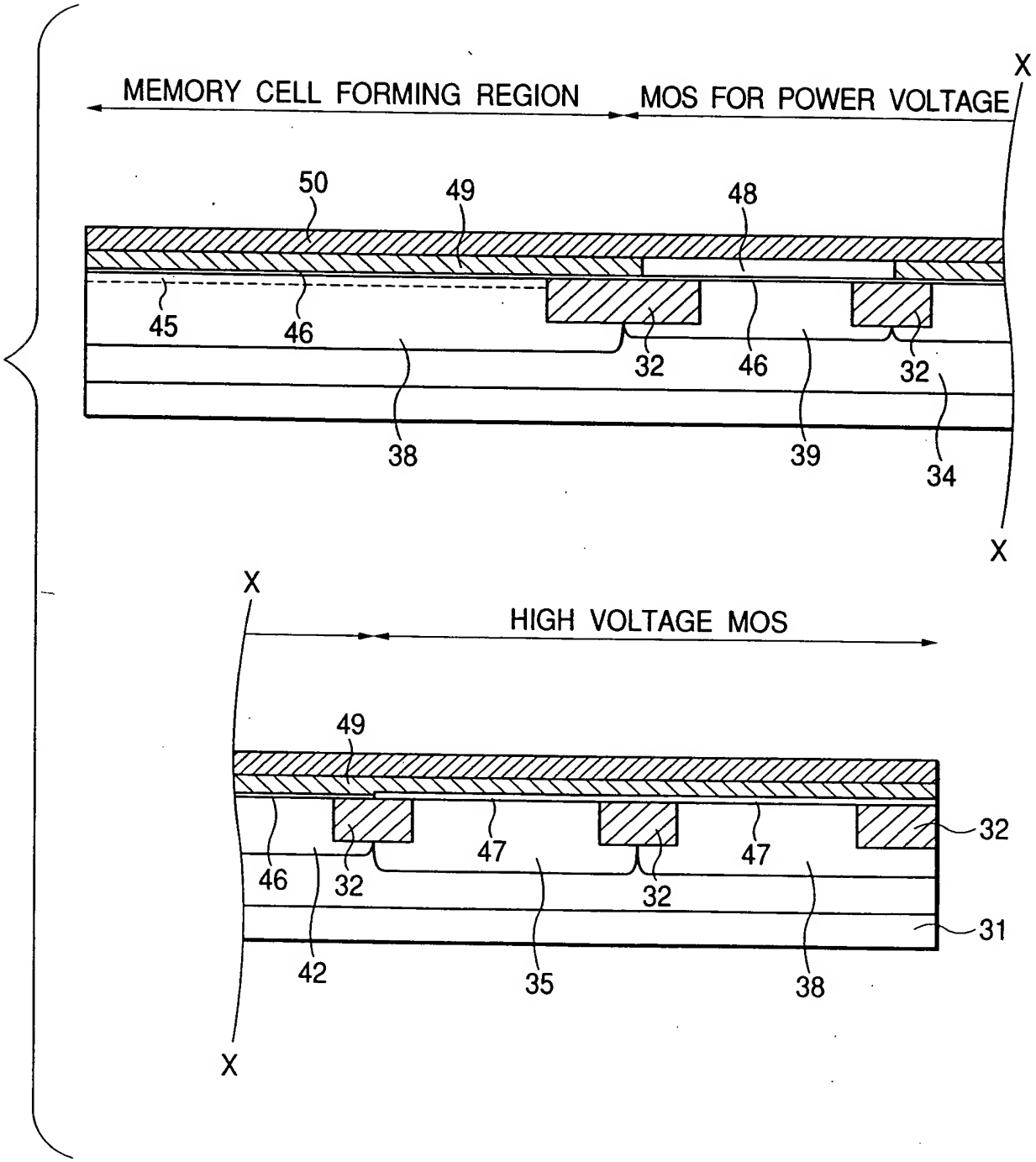

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
50
49
48
45
46
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
49
32
47
47
46
32
32
31
42
35
38
X

FIG. 20

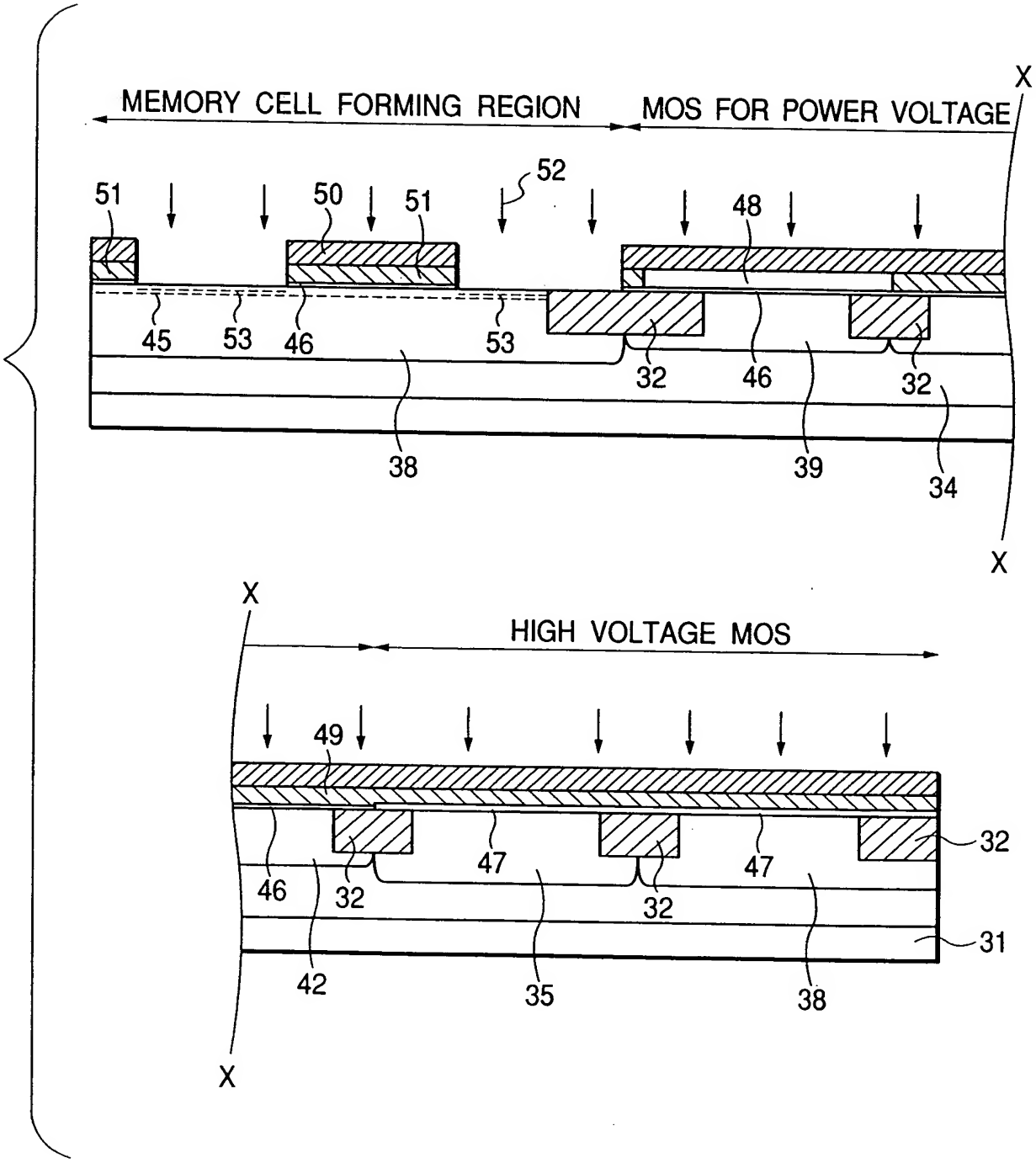

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
51
50
51
52
48
45
53
46
53
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
49
46
32
47
32
47
32
42
35
38
31
X

FIG. 21

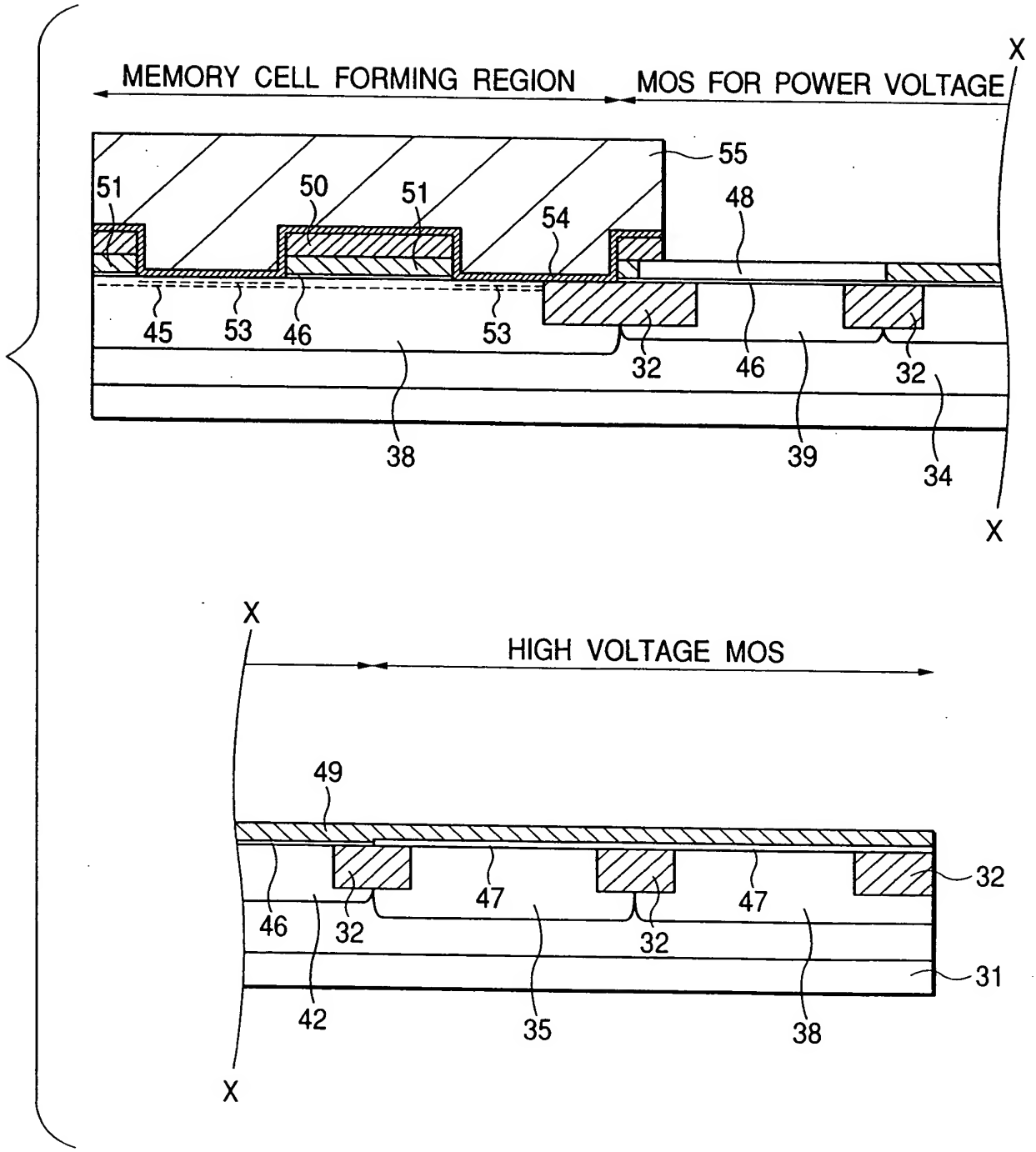

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
55
51
50
51
54
48
45
53
46
53
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
49
32
47
47
46
32
32
31
42
35
38
X

FIG. 22

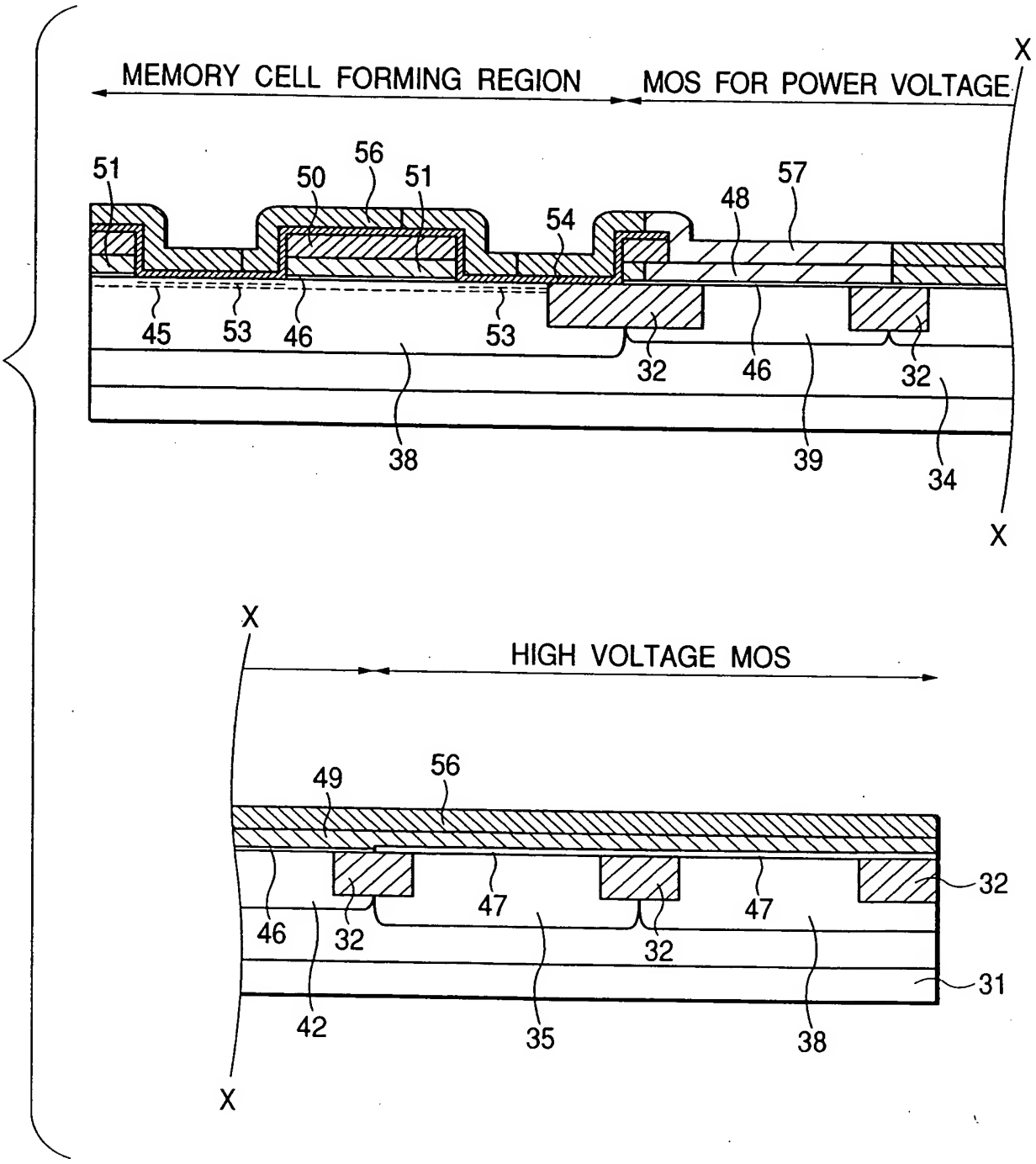

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
51
50
56
51
57
48
54
45
53
46
53
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
49
56
32
47
47
46
32
32
31
42
35
38
X

FIG. 23

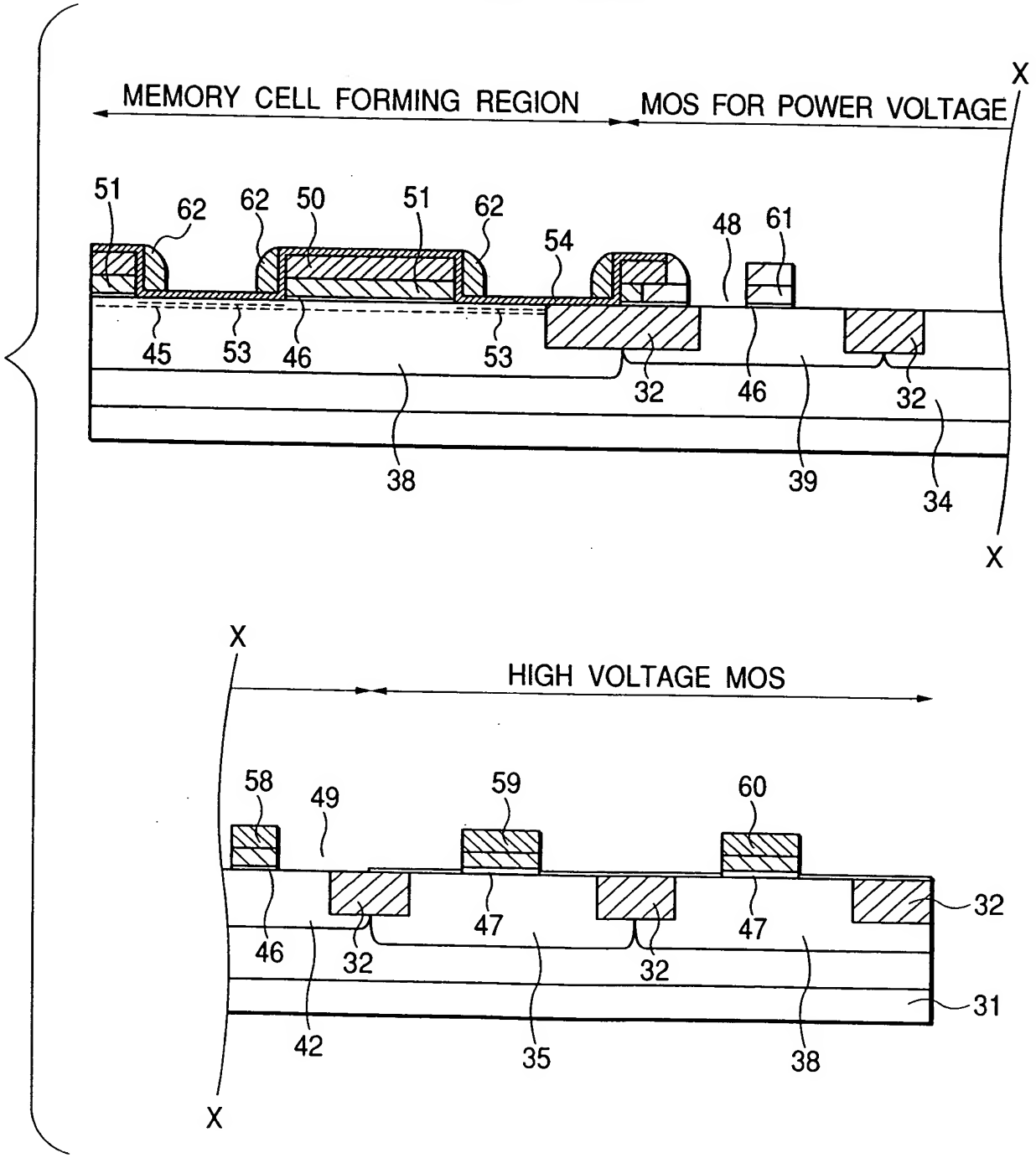

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
51
62
62
50
51
62
54
48
61
45
53
46
53
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
58
49
59
60
32
47
47
46
32
32
31
42
35
38
X

FIG. 24

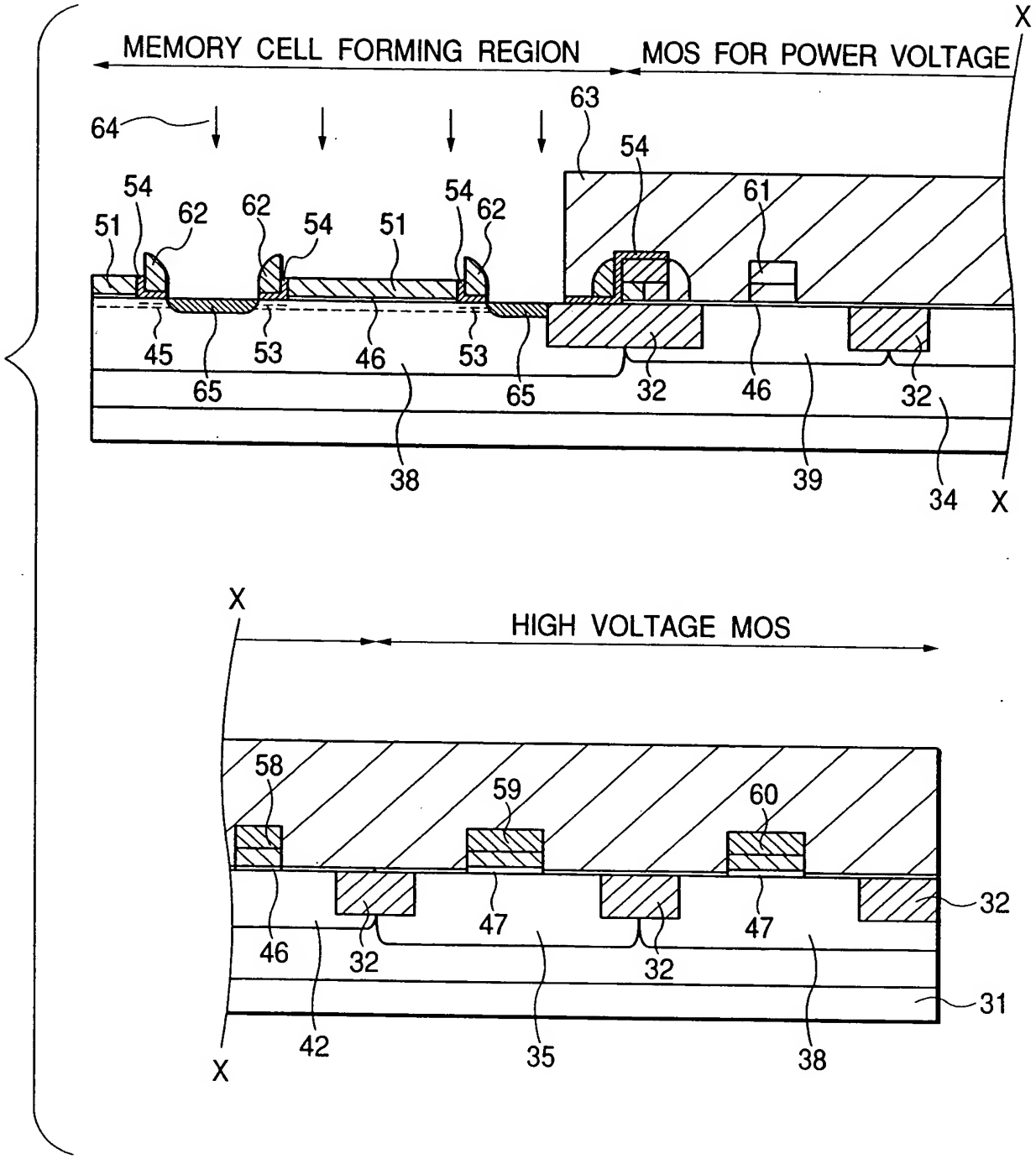

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
64
63
54
61
51
62
62
54
51
54
62
45
53
46
53
65
65
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
58
59
60
32
47
47
46
32
32
31
42
35
38
X

FIG. 25

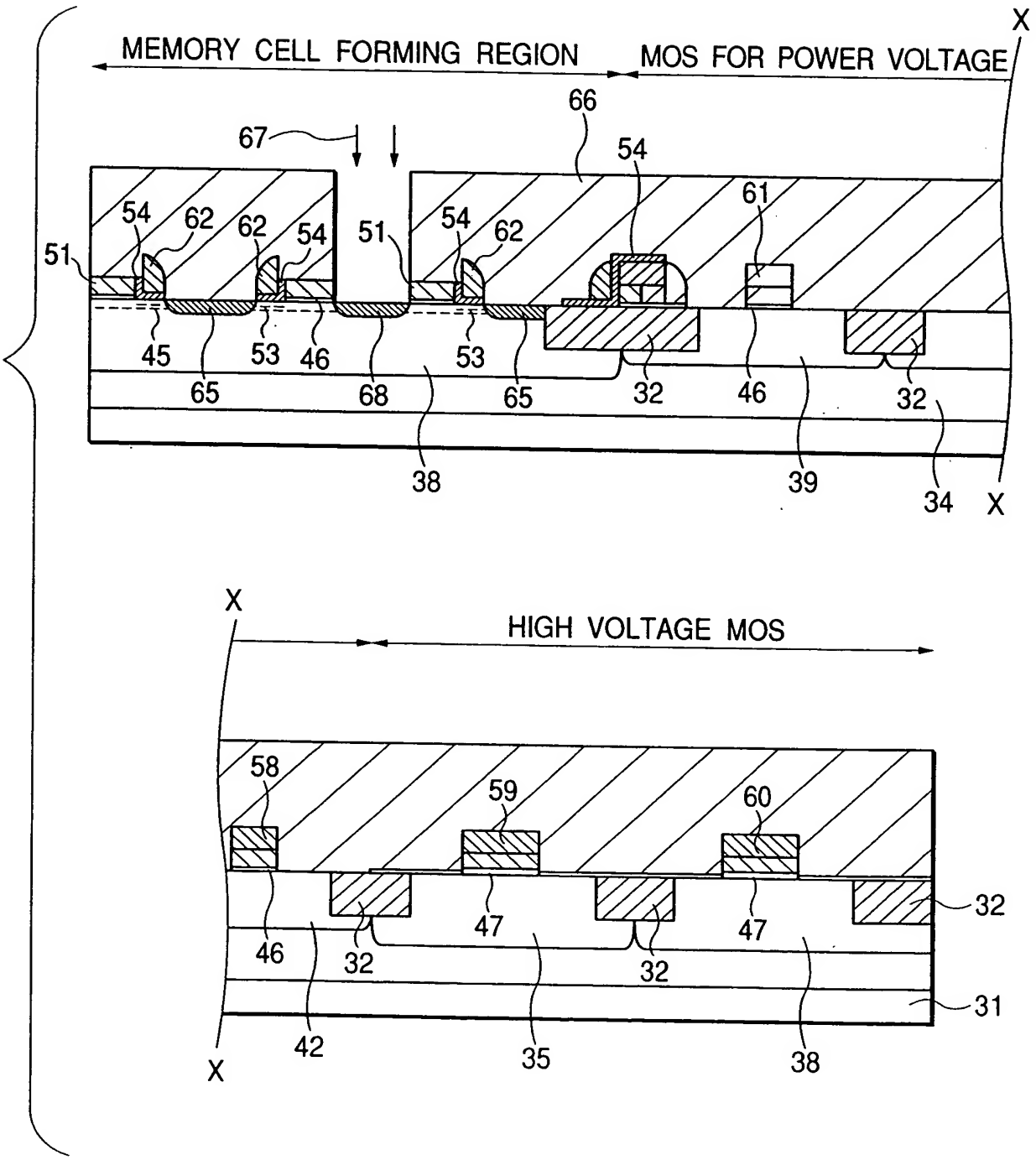

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
66
67
54
61
54
62
62
54
51
51
54
62
45
53
46
53
65
68
65
32
46
32
38
39
34
X
X
HIGH VOLTAGE MOS
58
59
60
32
47
47
46
32
32
31
42
35
38
X

FIG. 26

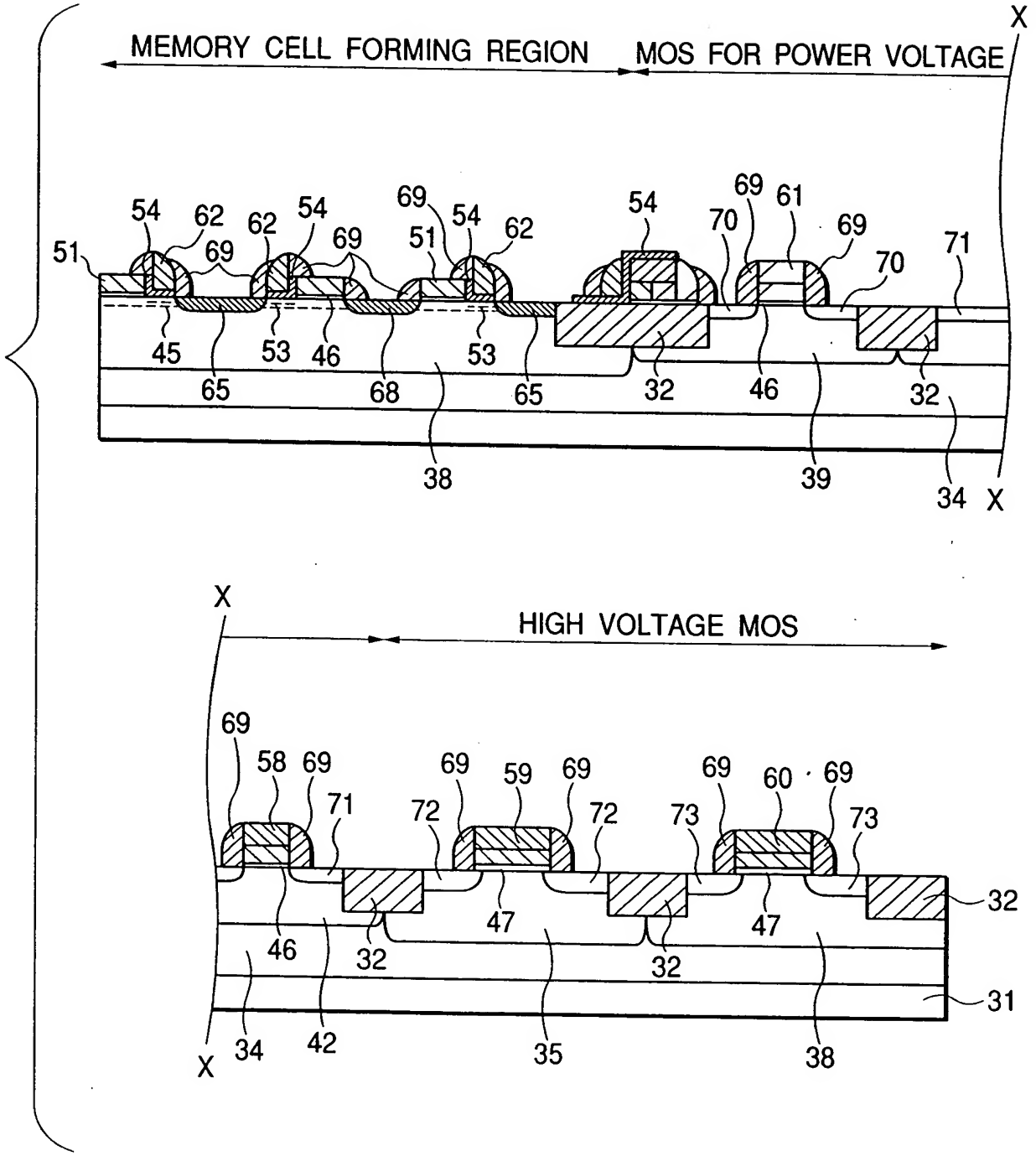

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
51
54
62
69
45
65
53
46
68
38
39
34
61
70
71
32
HIGH VOLTAGE MOS
58
59
60
72
73
47
42
35
31

FIG. 27

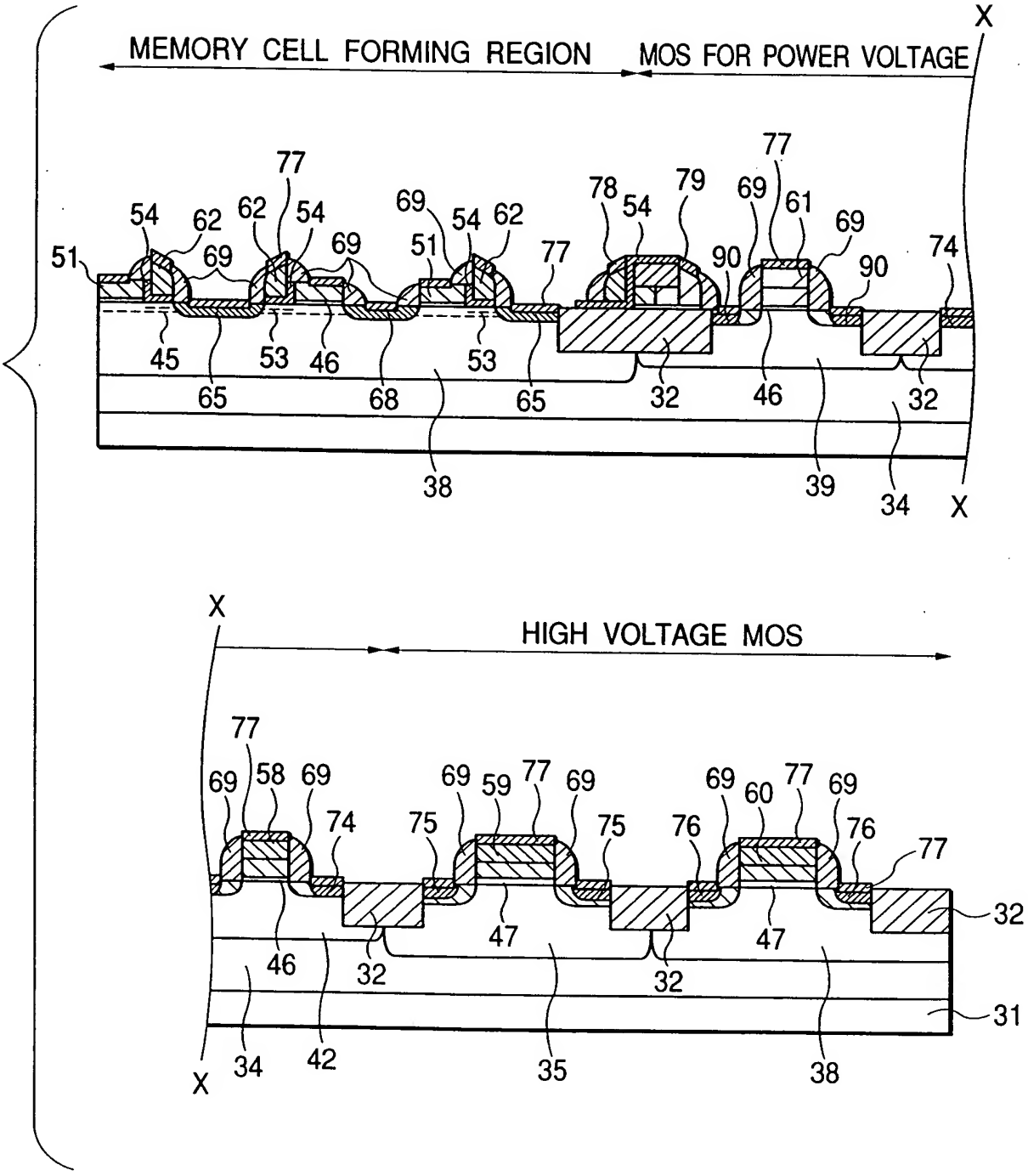

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
HIGH VOLTAGE MOS

FIG. 28

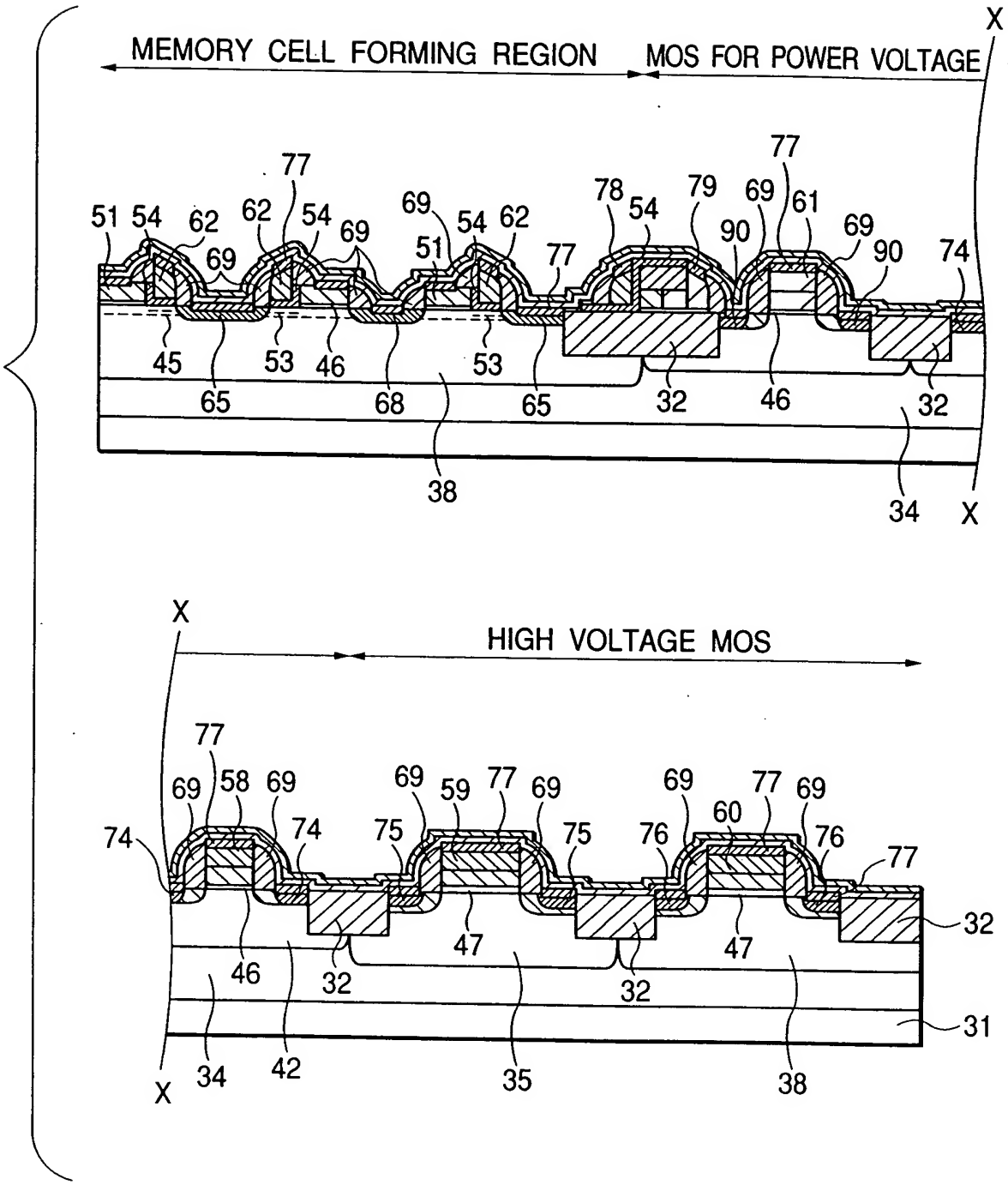

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
HIGH VOLTAGE MOS

FIG. 29

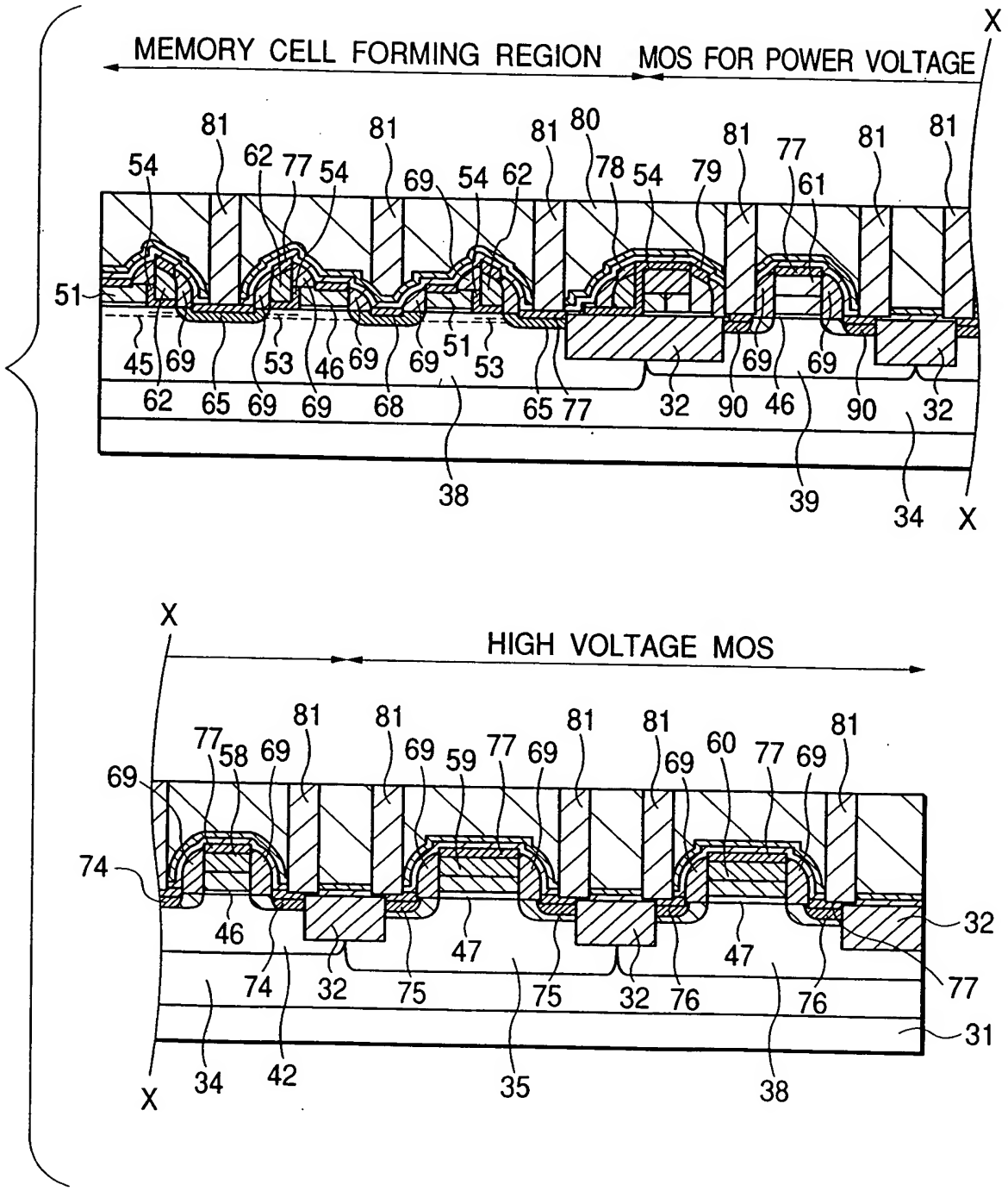

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
X
HIGH VOLTAGE MOS
X
81
80
77
61
54
62
69
78
79
51
45
53
46
68
65
32
90
38
39
34
60
58
59
74
47
75
76
42
35
31

FIG. 30

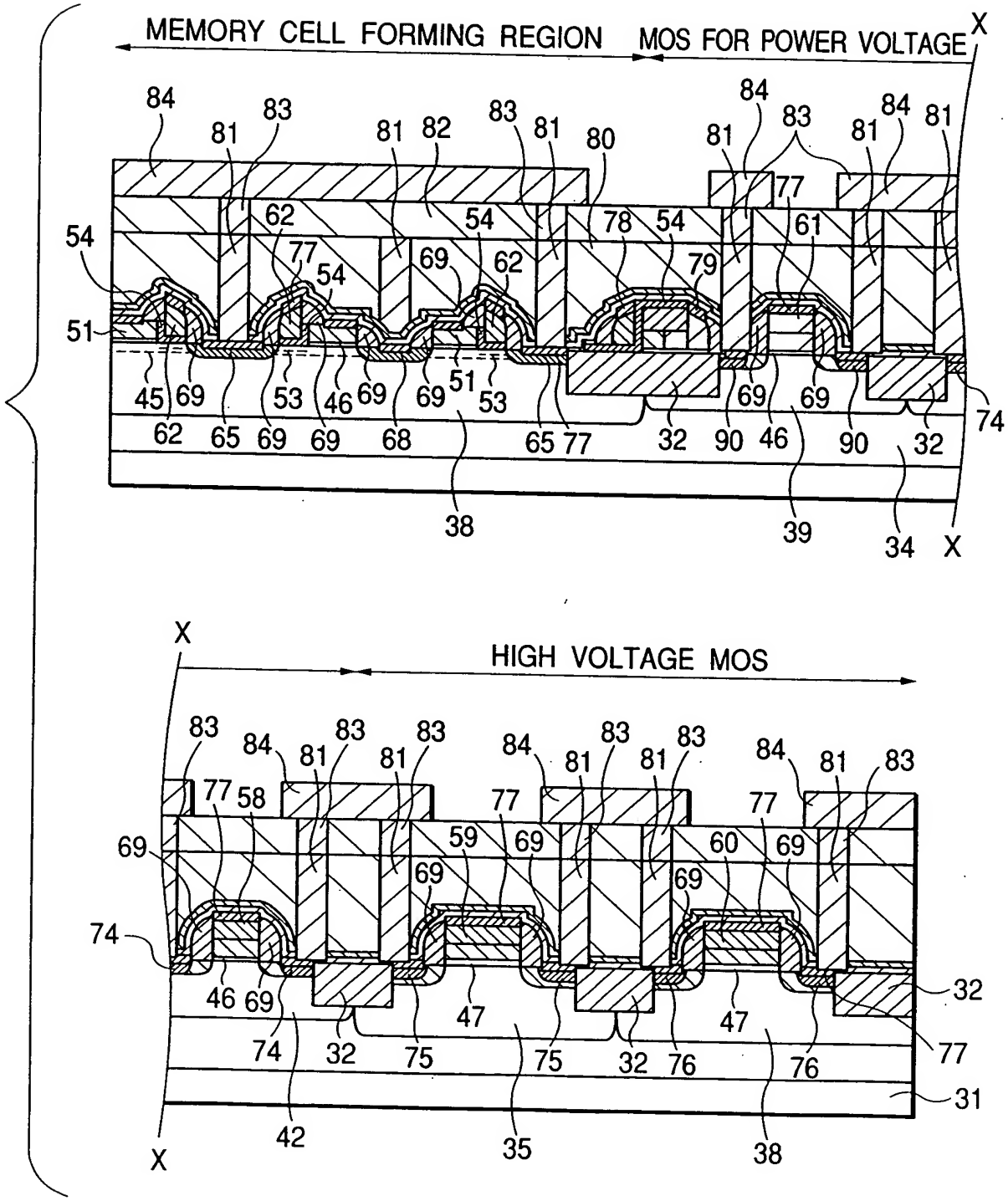

MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
HIGH VOLTAGE MOS
X

FIG. 31

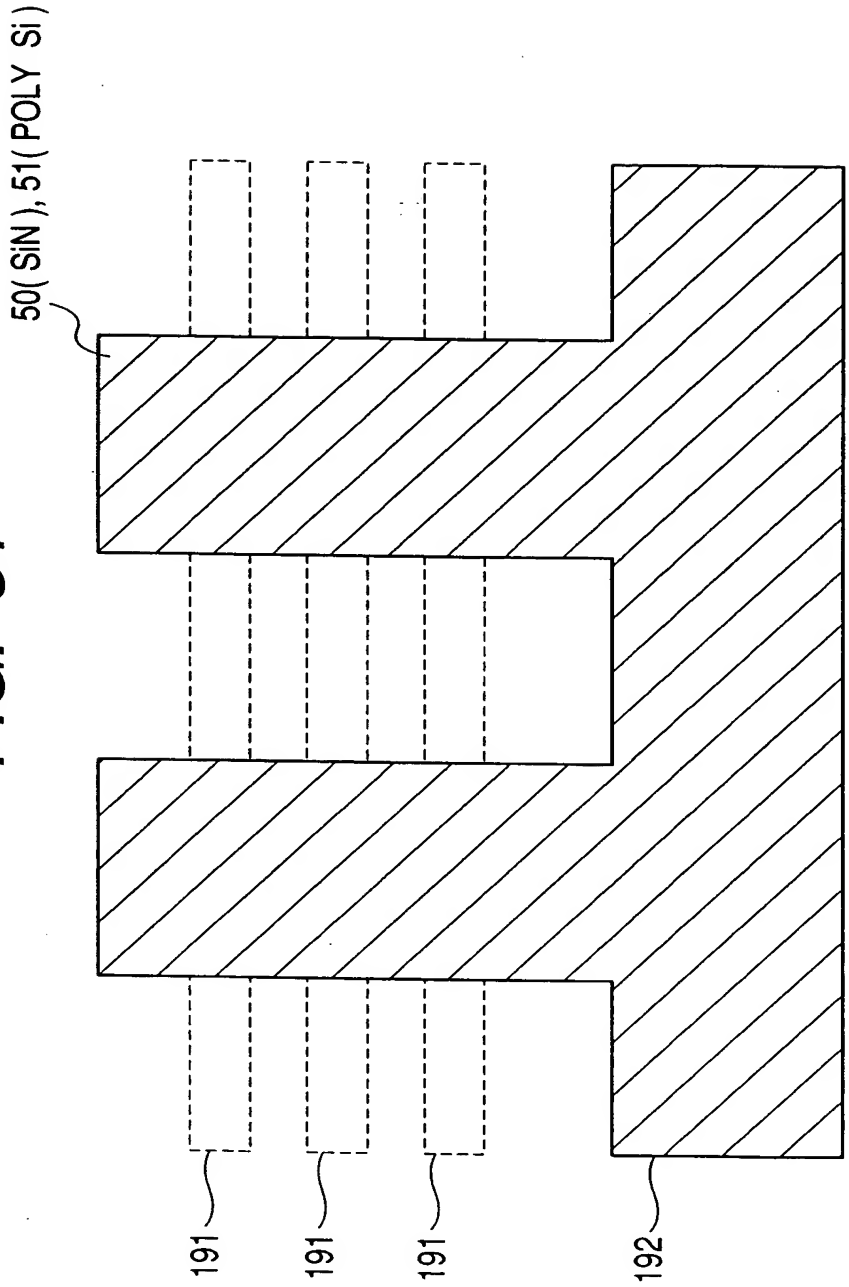


FIG. 32

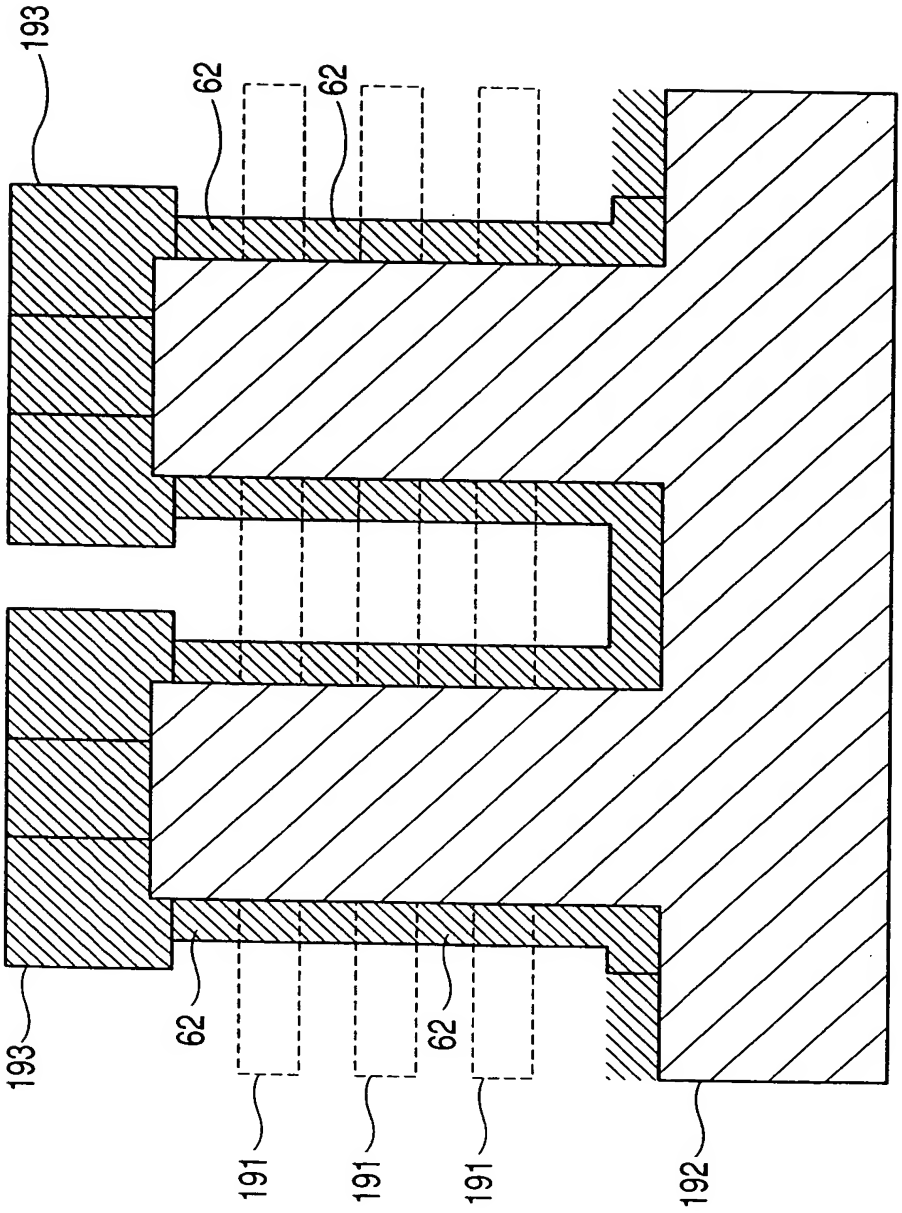


FIG. 33

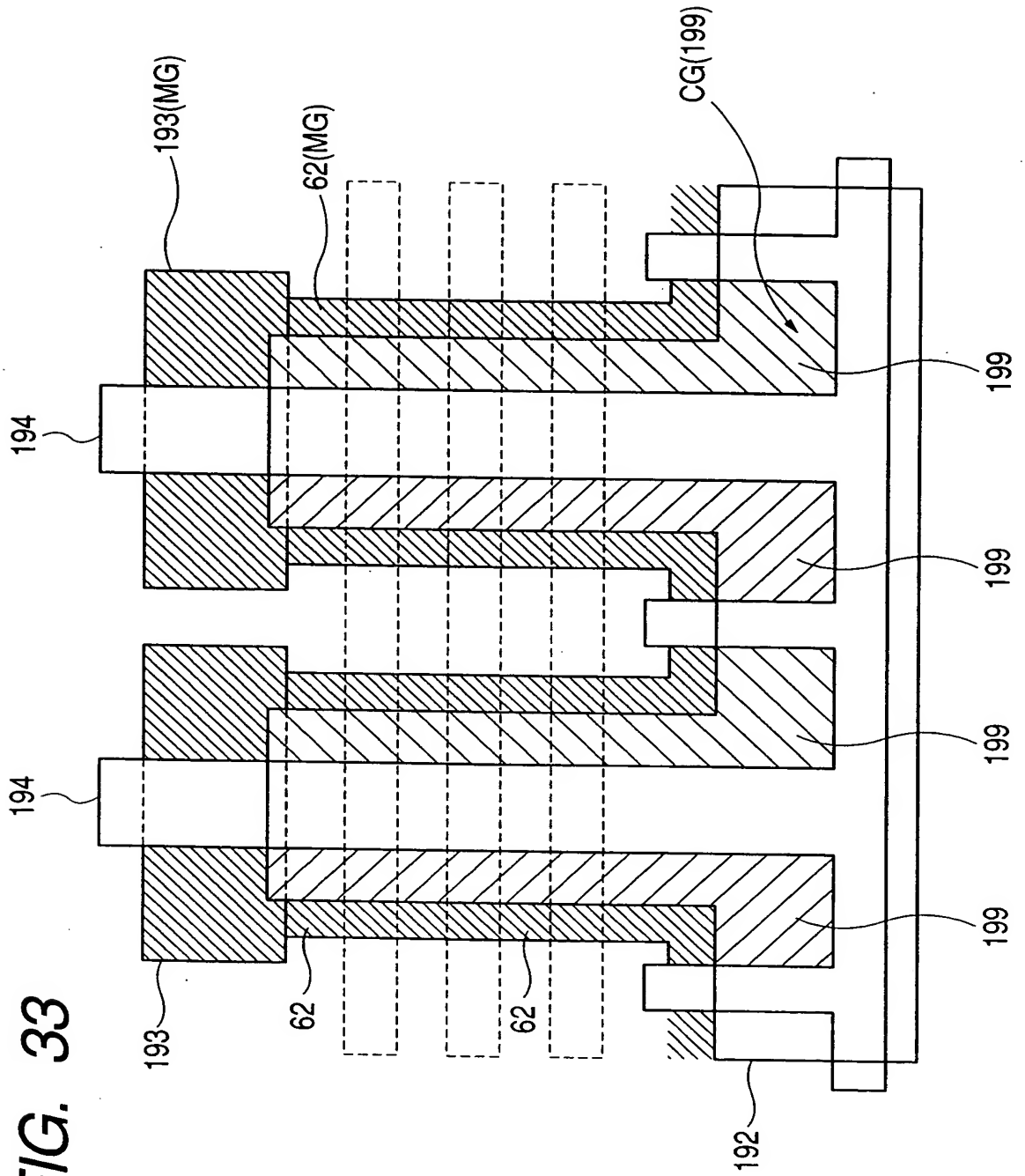
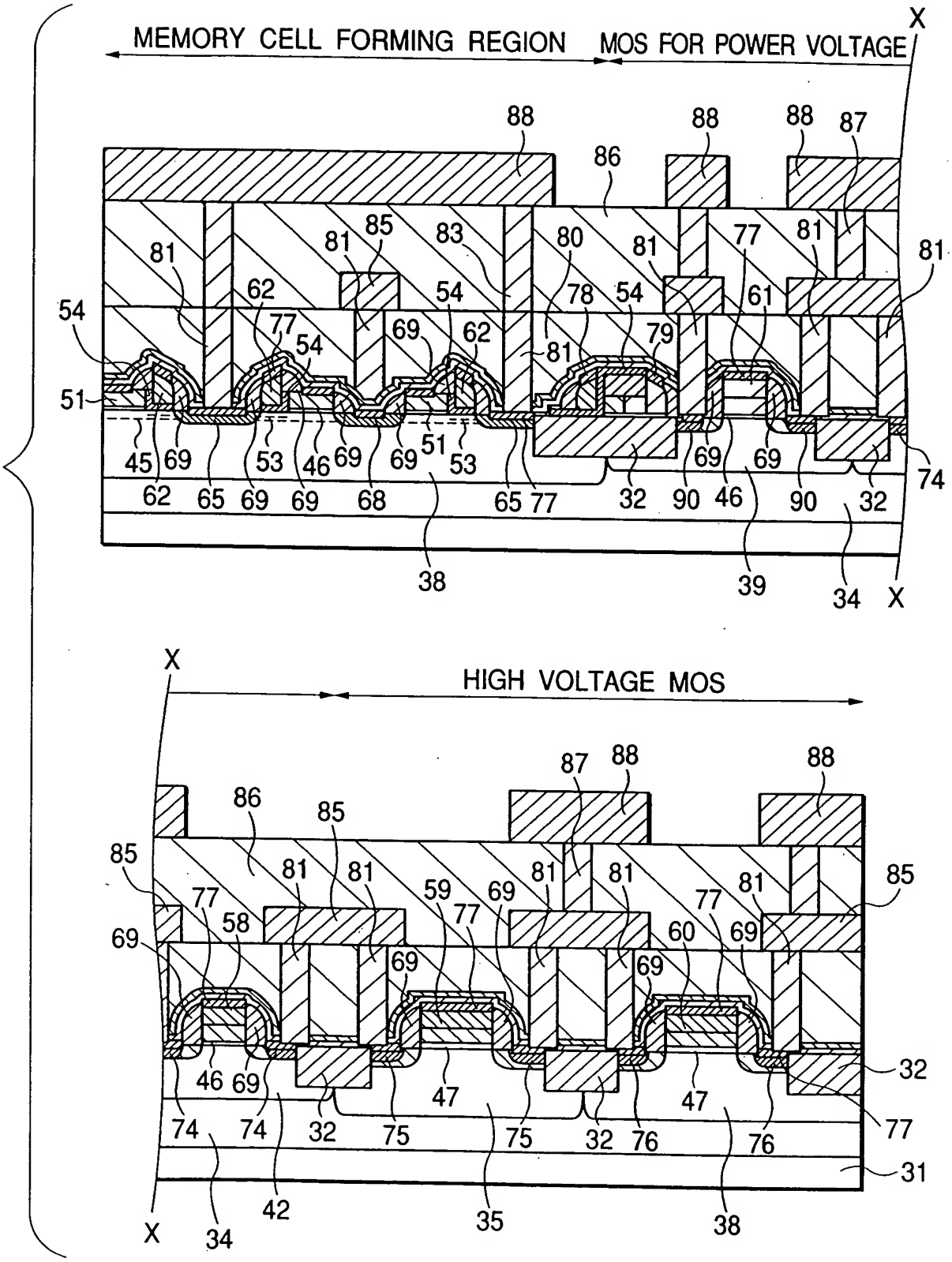


FIG. 34


MEMORY CELL FORMING REGION
MOS FOR POWER VOLTAGE
X
88
88
88
87
86
85
83
81
81
80
81
77
81
81
62
54
54
78
54
61
54
77
54
69
62
81
79
51
45
69
53
46
69
69
51
53
69
69
74
62
65
69
69
68
65
77
32
90
46
90
32
38
39
34
X
HIGH VOLTAGE MOS
X
87
88
88
86
85
85
81
81
59
69
81
81
81
85
77
58
77
77
69
60
69
69
69
69
32
46
69
47
47
74
74
32
75
75
32
76
76
77
31
42
35
38
X
34

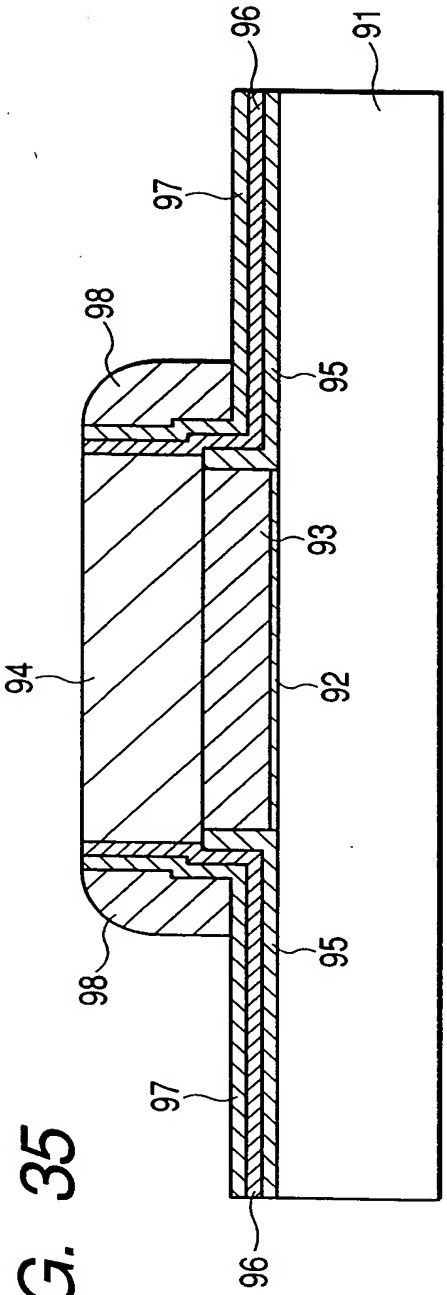

96
91
97
98
95
93
94
92
98
95
97
96

FIG. 35

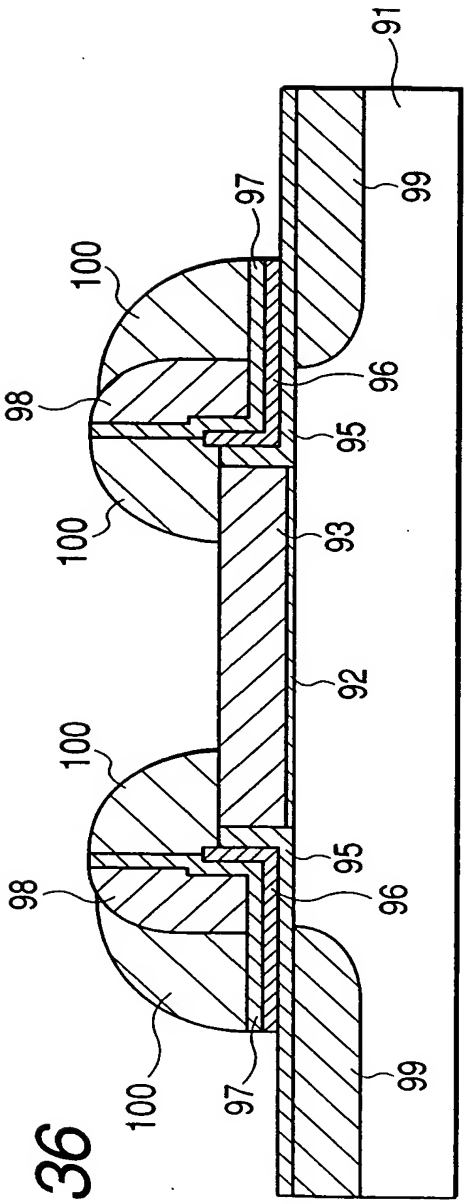

91
97
99
100
98
96
95
100
93
92
100
95
98
96
100
97
99

FIG. 36

FIG. 37

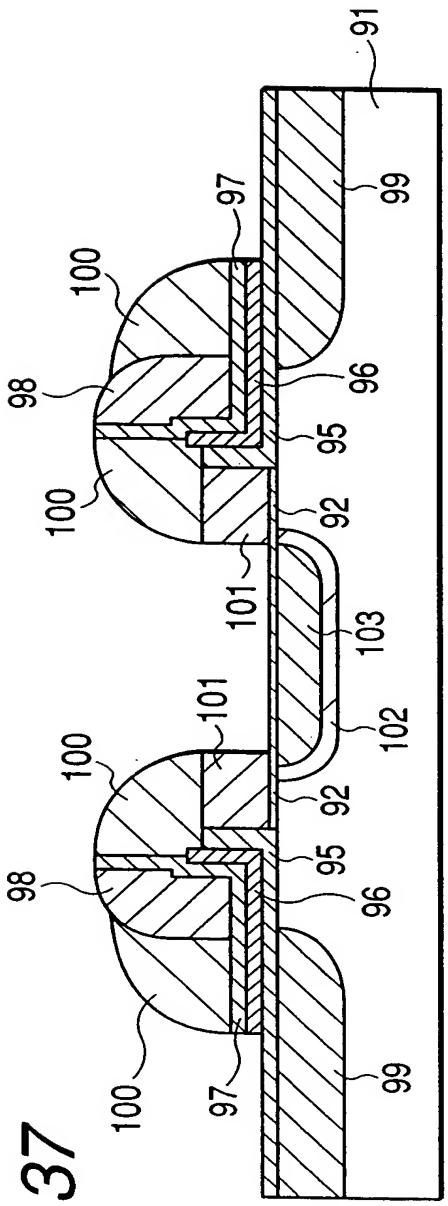

91
99
97
100
98
96
95
92
101
103
102
100
97
99

FIG. 38

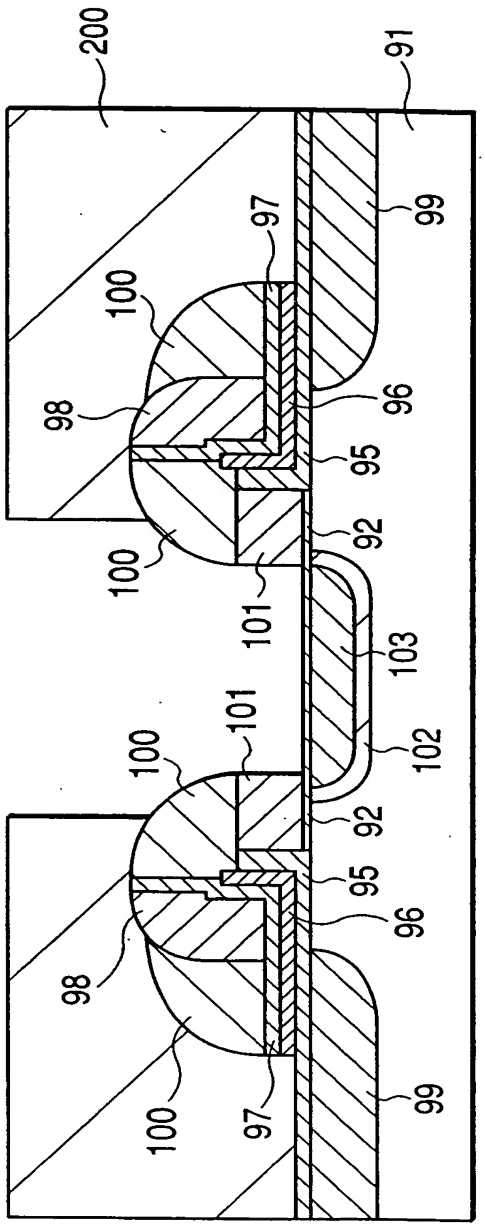
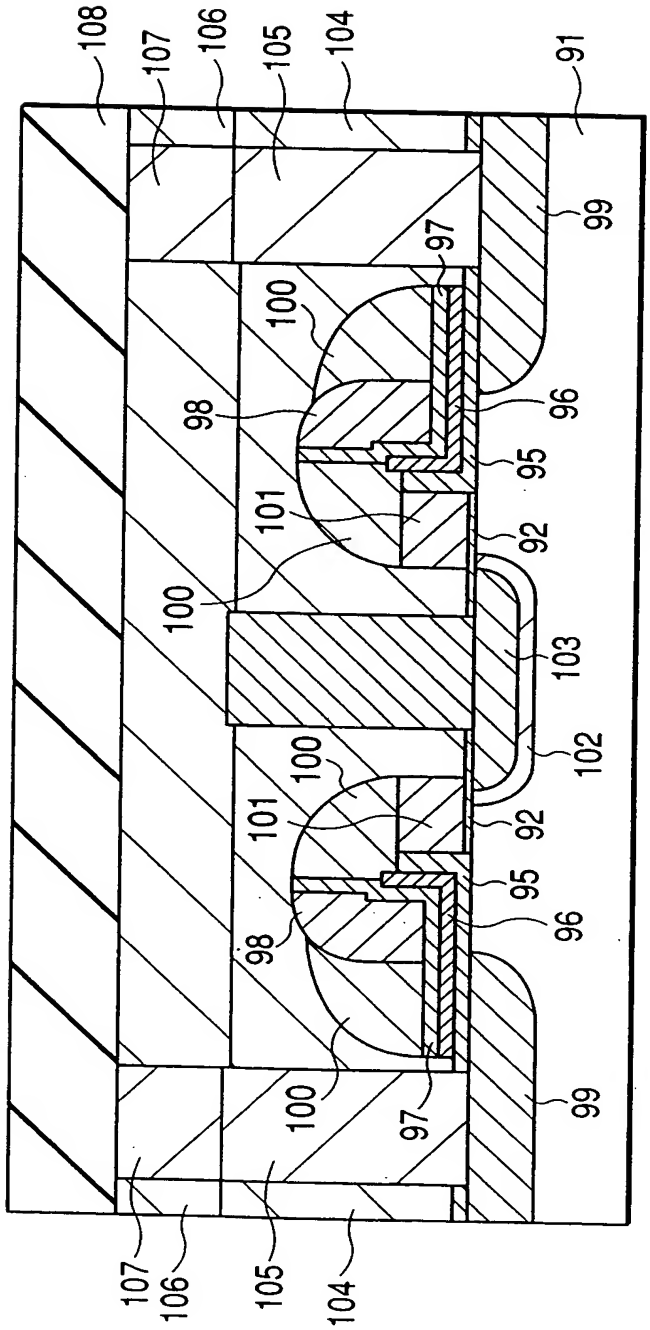

200
91
99
97
100
98
96
95
92
101
103
102
100
97
99

FIG. 39


108
107
106
105
104
91
99
97
100
98
96
95
101
92
100
103
102
100
101
92
95
96
98
100
97
99
107
106
105
104

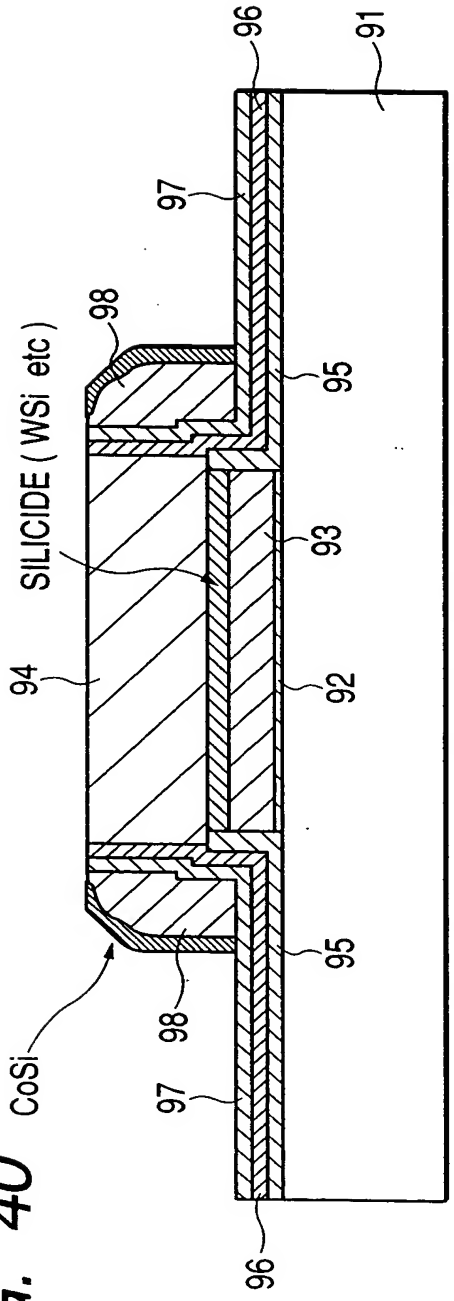

96
91
97
98
SILICIDE (WSi etc)
95
93
94
92
95
CoSi
98
97
96

FIG. 40

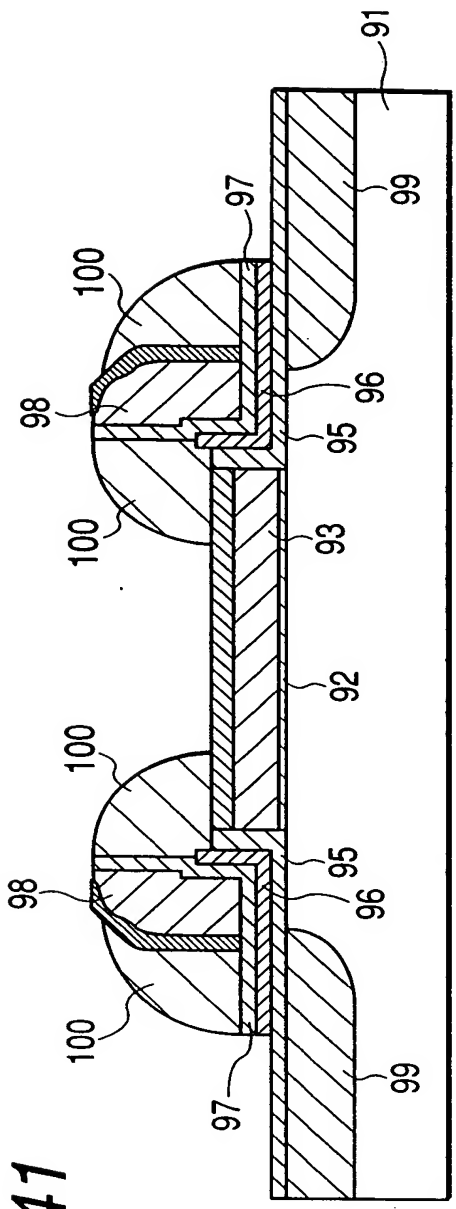

91
99
97
100
98
96
95
100
93
92
100
95
98
96
100
97
99

FIG. 41

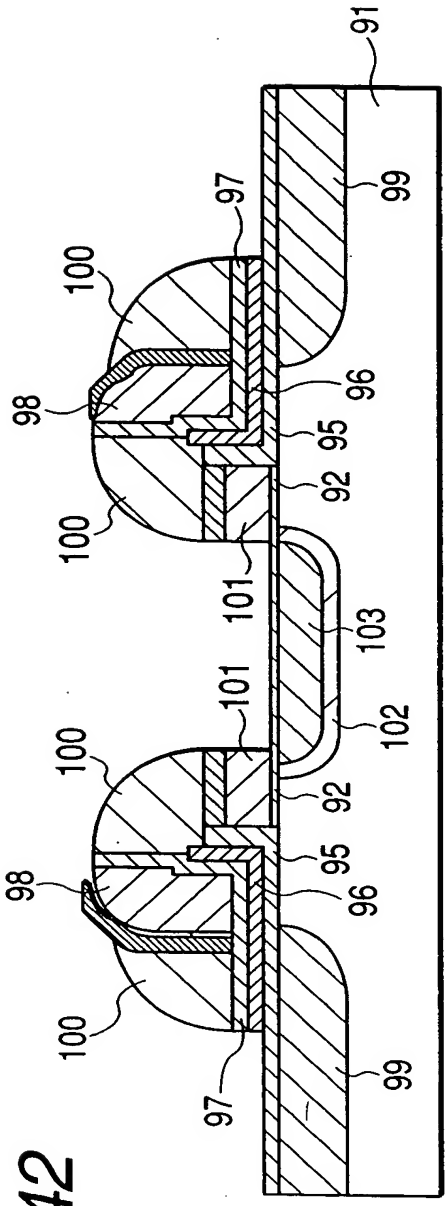

91
97
99
100
98
96
95
92
101
103
102

FIG. 42

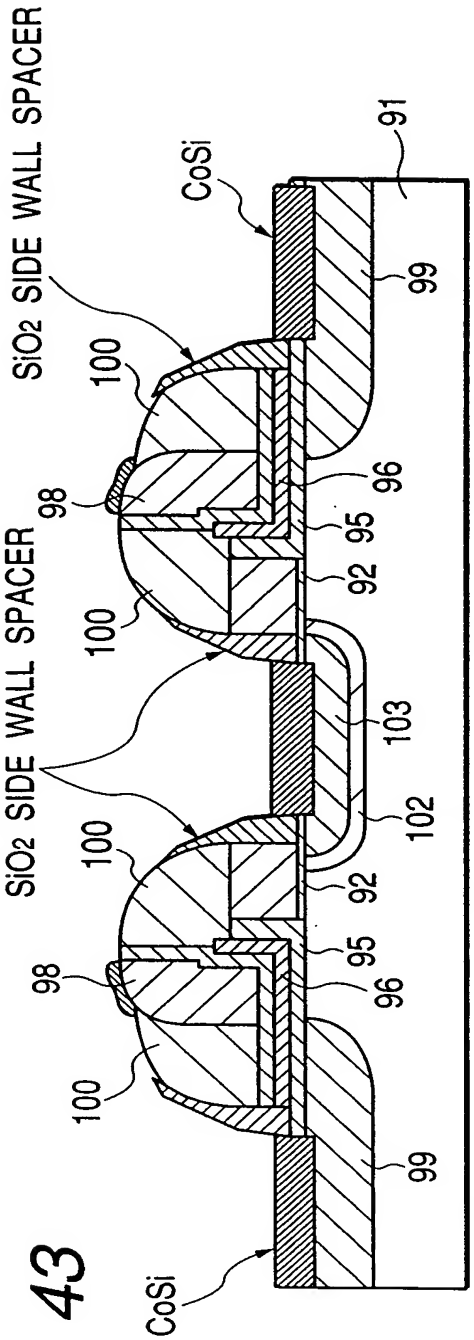

SiO2 SIDE WALL SPACER
SiO2 SIDE WALL SPACER
CoSi
CoSi
91
99
100
98
96
95
92
103
102

FIG. 43

FIG. 44

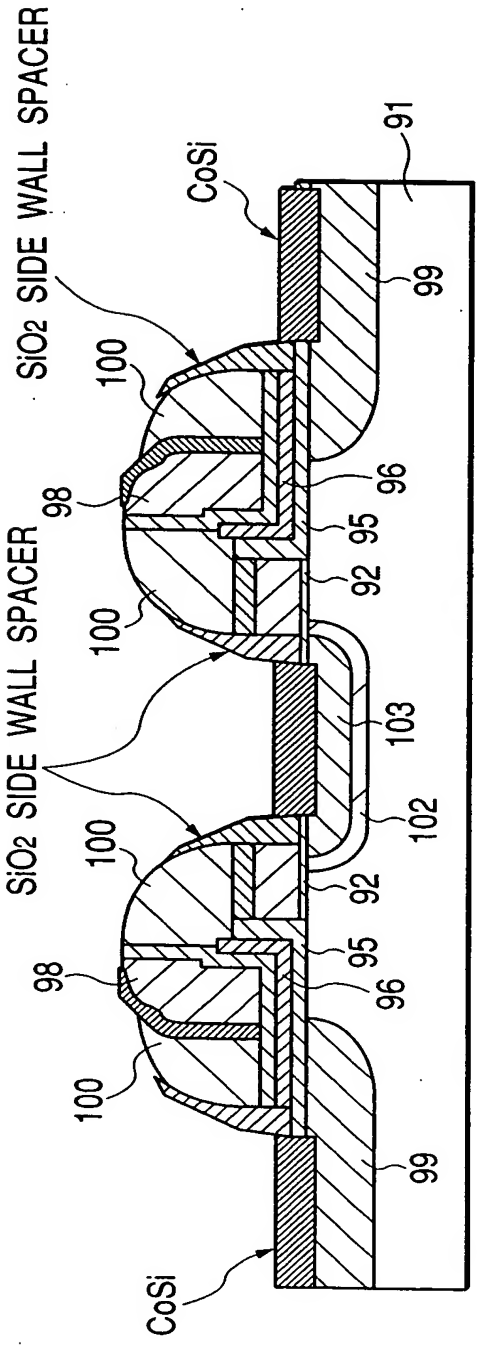

SiO2 SIDE WALL SPACER
SiO2 SIDE WALL SPACER
SiO2 SIDE WALL SPACER
CoSi
CoSi
91
99
99
100
100
100
100
98
98
96
96
95
95
92
92
103
102

FIG. 45

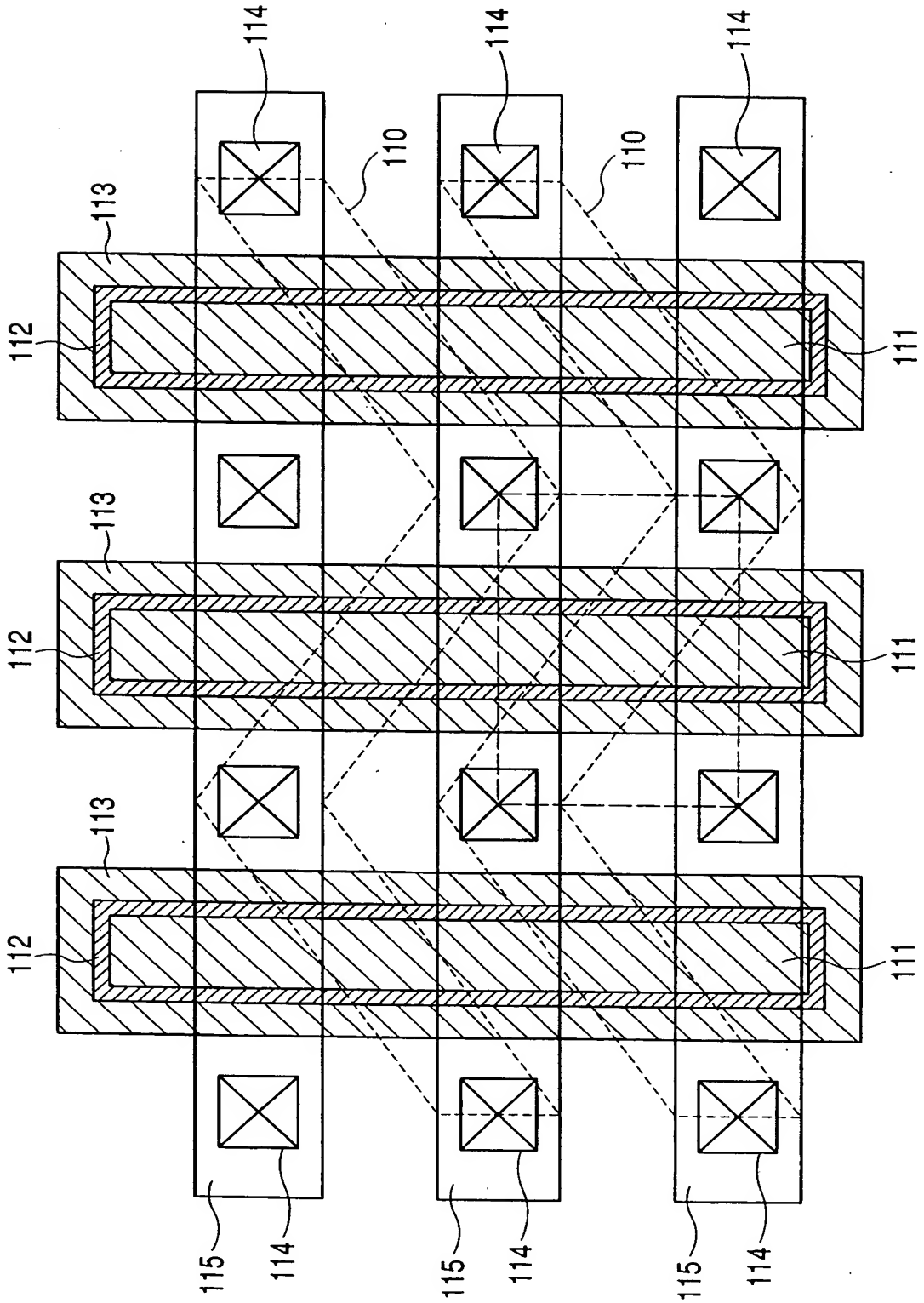


FIG. 46

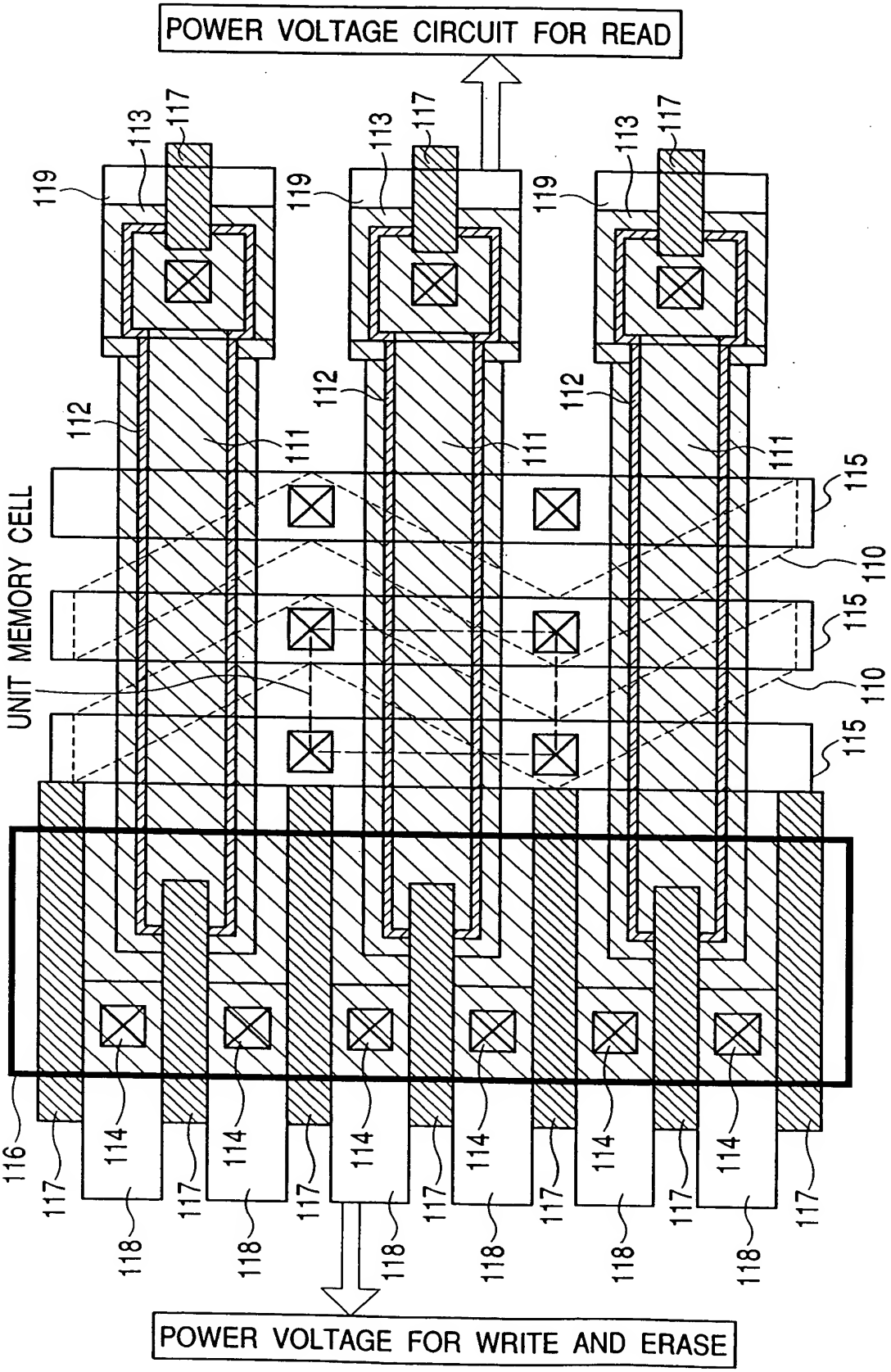

POWER VOLTAGE CIRCUIT FOR READ
UNIT MEMORY CELL
POWER VOLTAGE FOR WRITE AND ERASE
111
112
113
114
115
116
117
118
119
110

FIG. 47

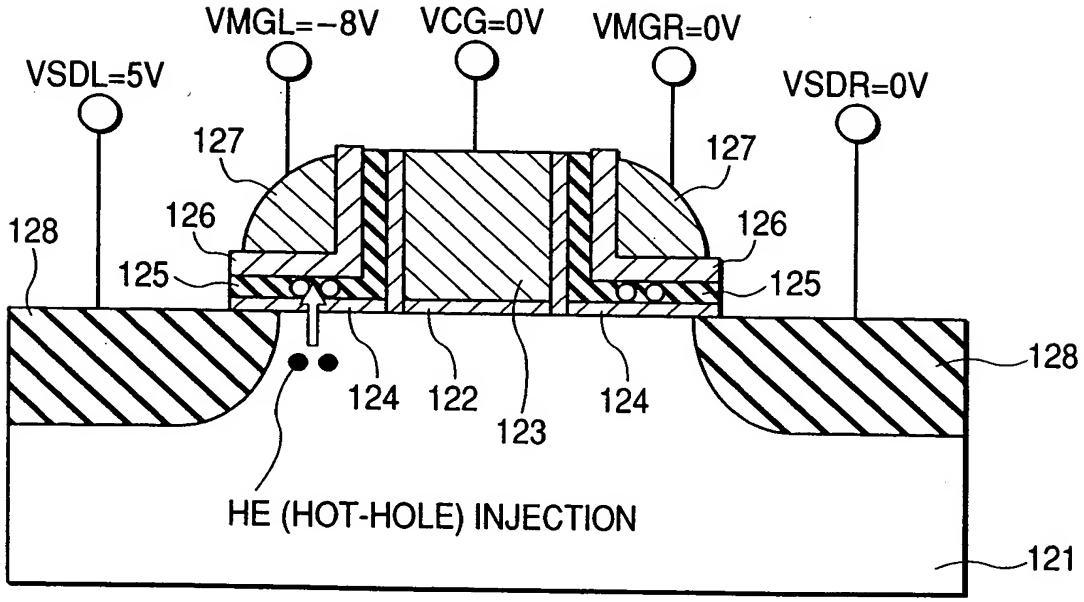

VMGL=−8V
VCG=0V
VMGR=0V
VSDL=5V
VSDR=0V
127
127
126
126
128
125
125
128
124
122
123
124
HE (HOT-HOLE) INJECTION
121

FIG. 48

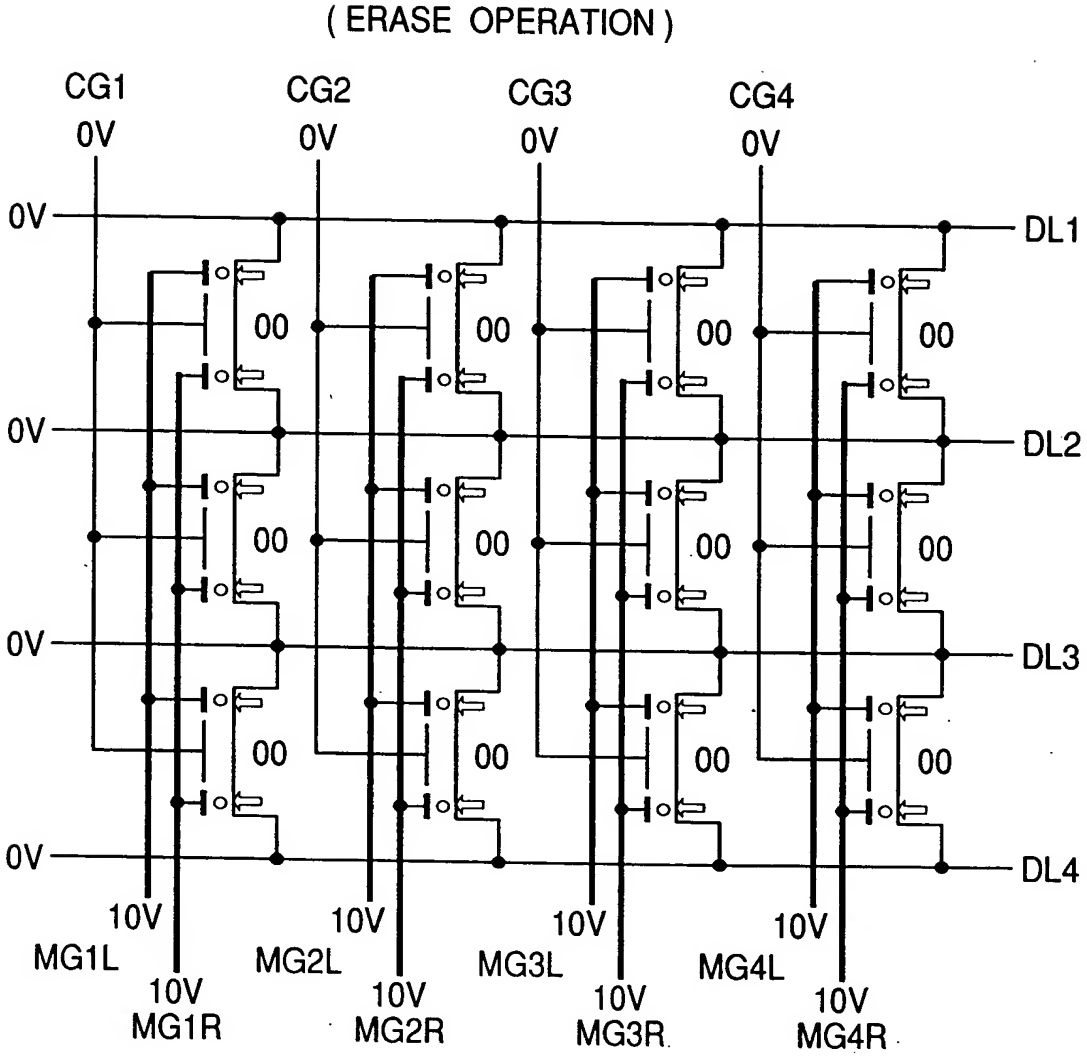

(ERASE OPERATION)
CG1
0V
CG2
0V
CG3
0V
CG4
0V
0V
0V
0V
0V
DL1
DL2
DL3
DL4
00
10V
MG1L
10V
MG1R
10V
MG2L
10V
MG2R
10V
MG3L
10V
MG3R
10V
MG4L
10V
MG4R

FIG. 49

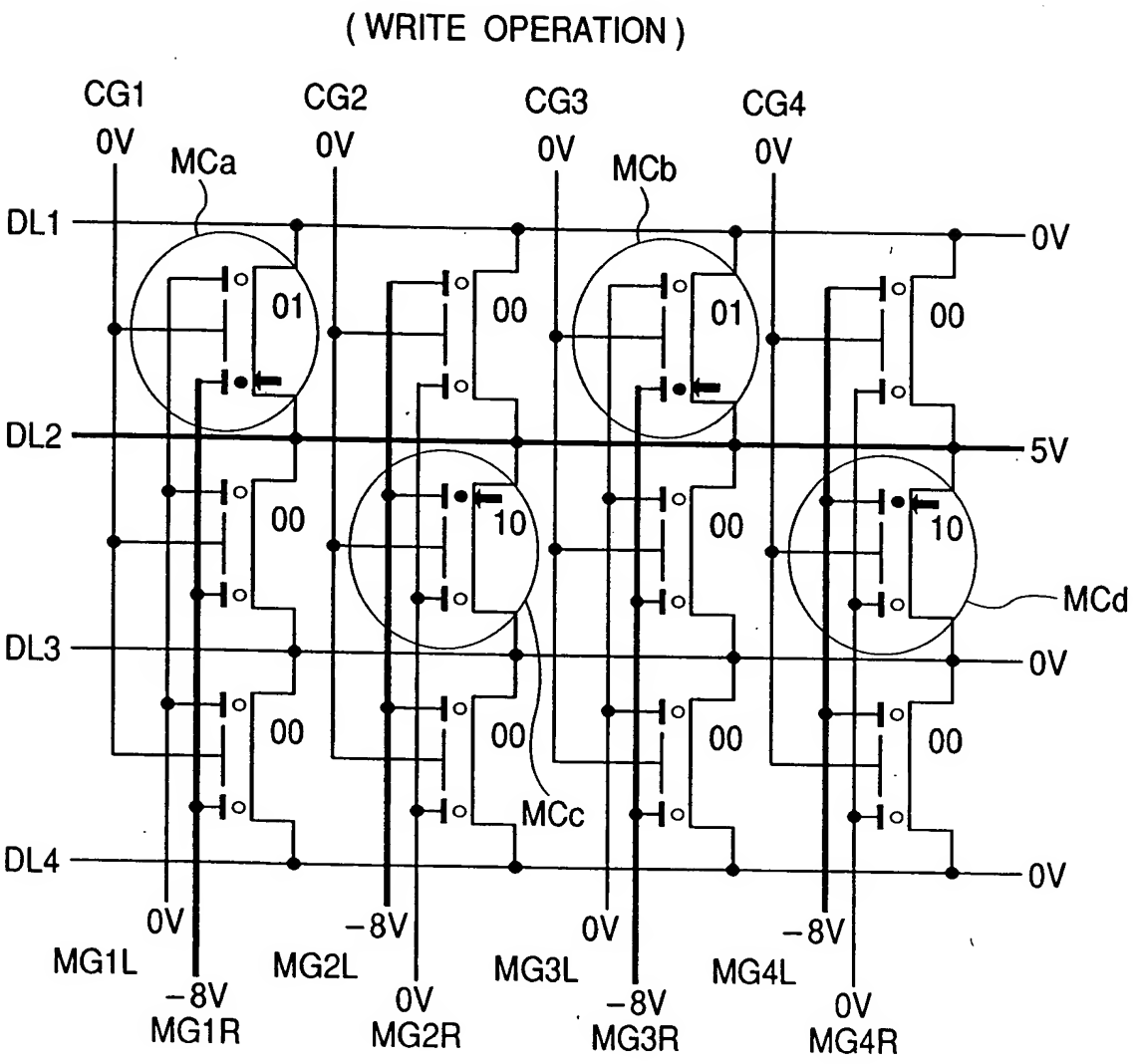

(WRITE OPERATION)
CG1
0V
CG2
0V
CG3
0V
CG4
0V
MCa
MCb
MCc
MCd
DL1
DL2
DL3
DL4
0V
5V
01
00
10
MG1L
MG2L
MG3L
MG4L
MG1R
MG2R
MG3R
MG4R
−8V

FIG. 50

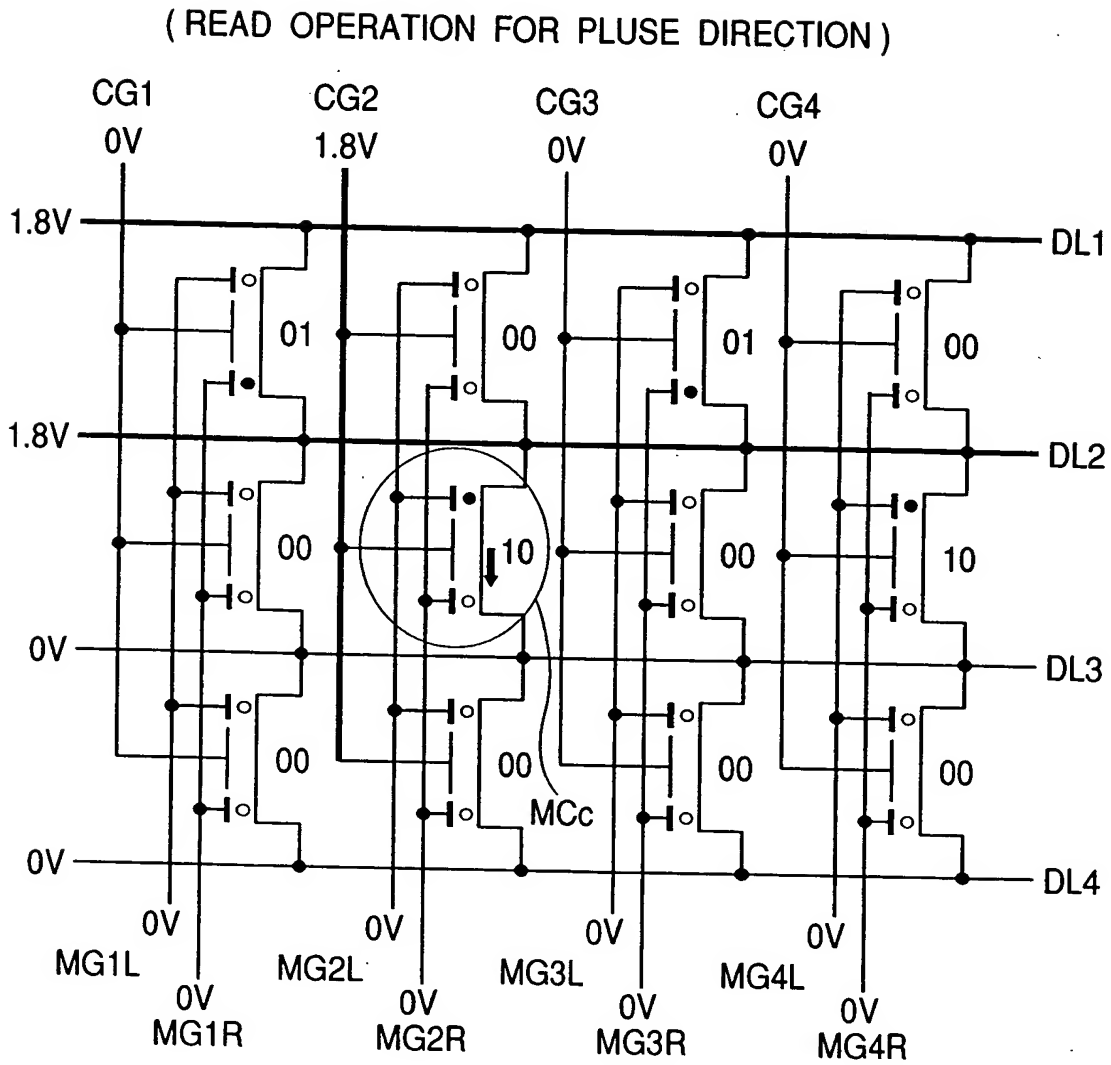

(READ OPERATION FOR PLUSE DIRECTION)
CG1
0V
CG2
1.8V
CG3
0V
CG4
0V
1.8V
DL1
01
00
01
00
1.8V
DL2
00
10
00
10
0V
DL3
00
00
00
00
MCc
0V
DL4
0V
0V
0V
0V
MG1L
MG2L
MG3L
MG4L
0V
0V
0V
0V
MG1R
MG2R
MG3R
MG4R

FIG. 51

(READ OPERATION FOR REVERSE DIRECTION)

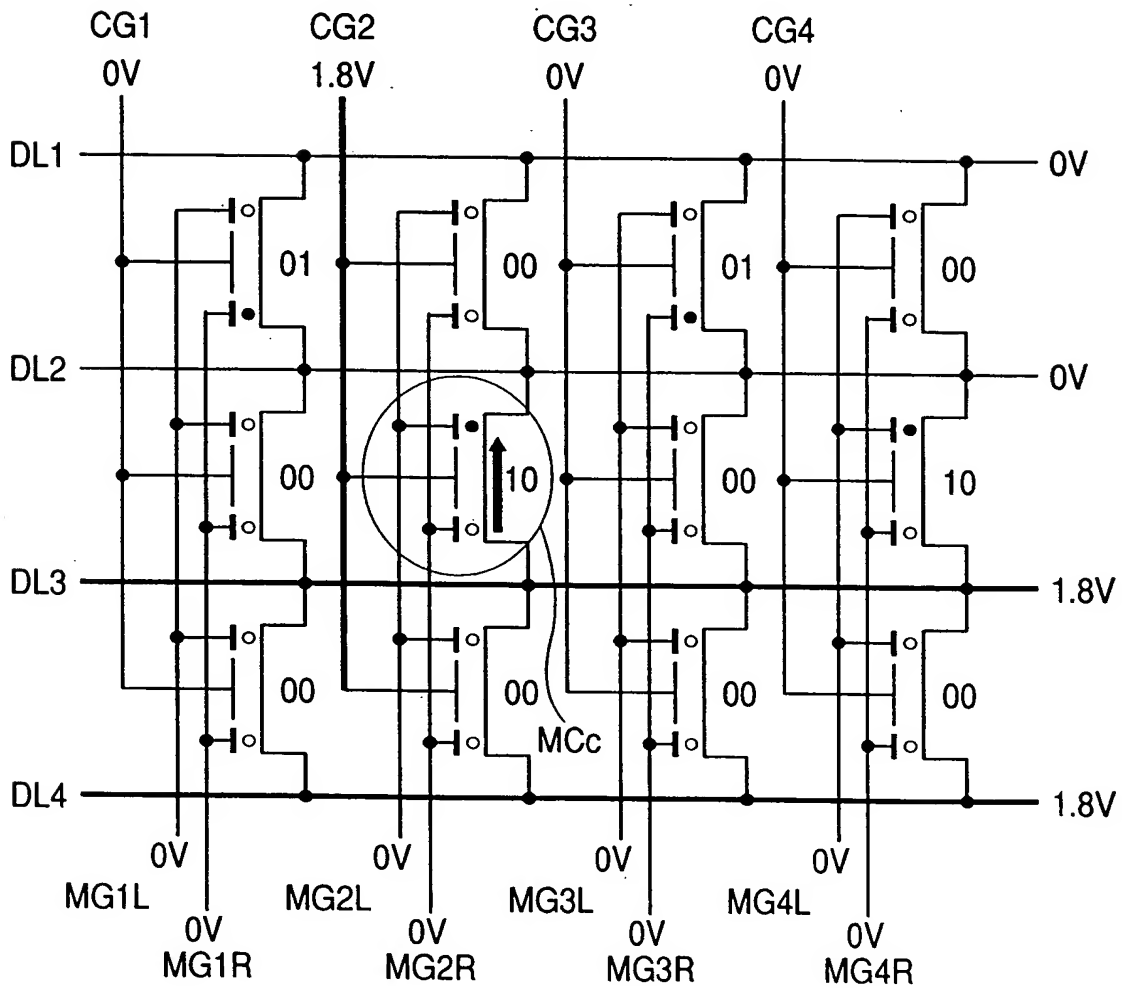


FIG. 52

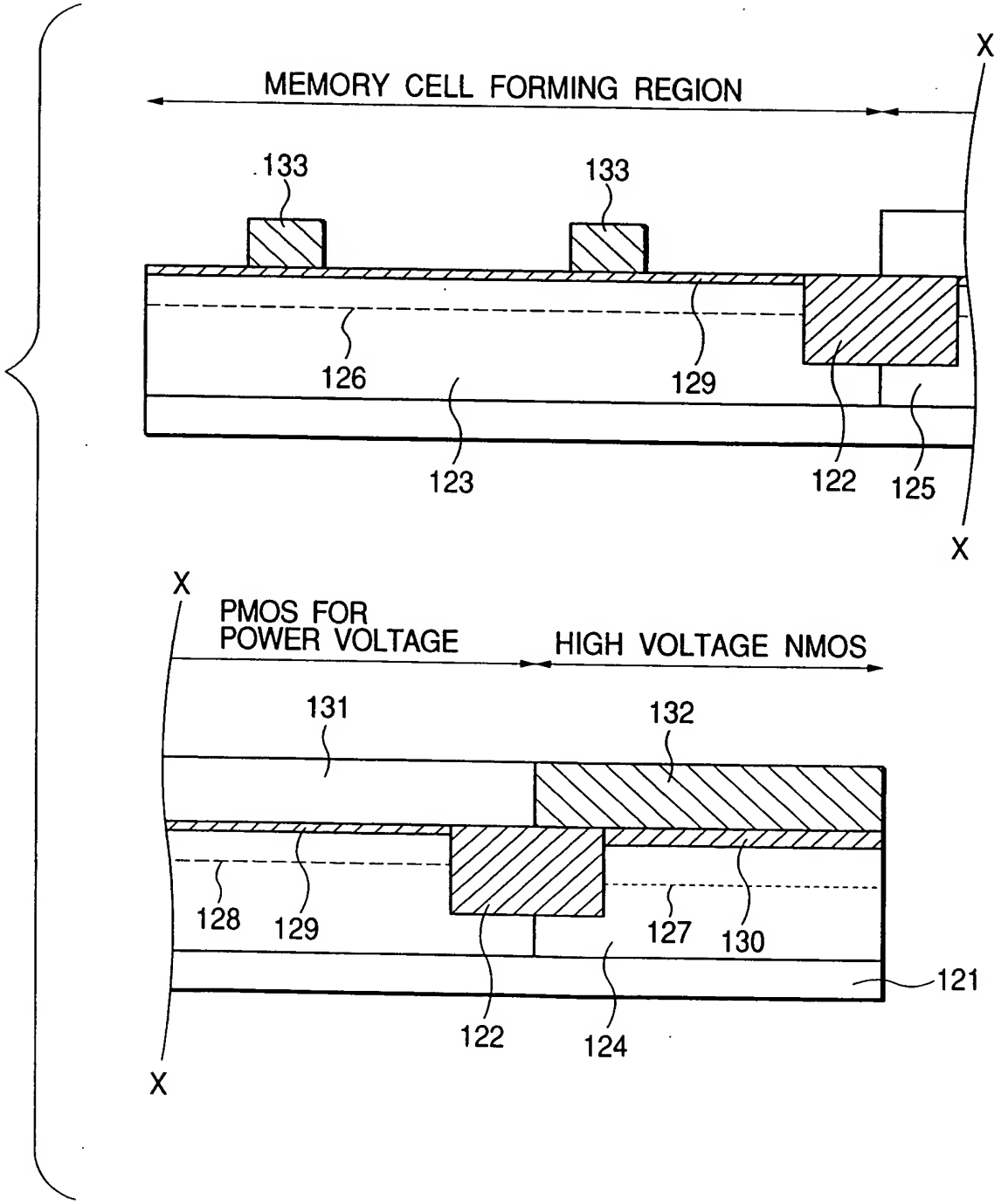

MEMORY CELL FORMING REGION
X
133
133
126
129
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
131
132
128
129
127
130
121
122
124
X

FIG. 53

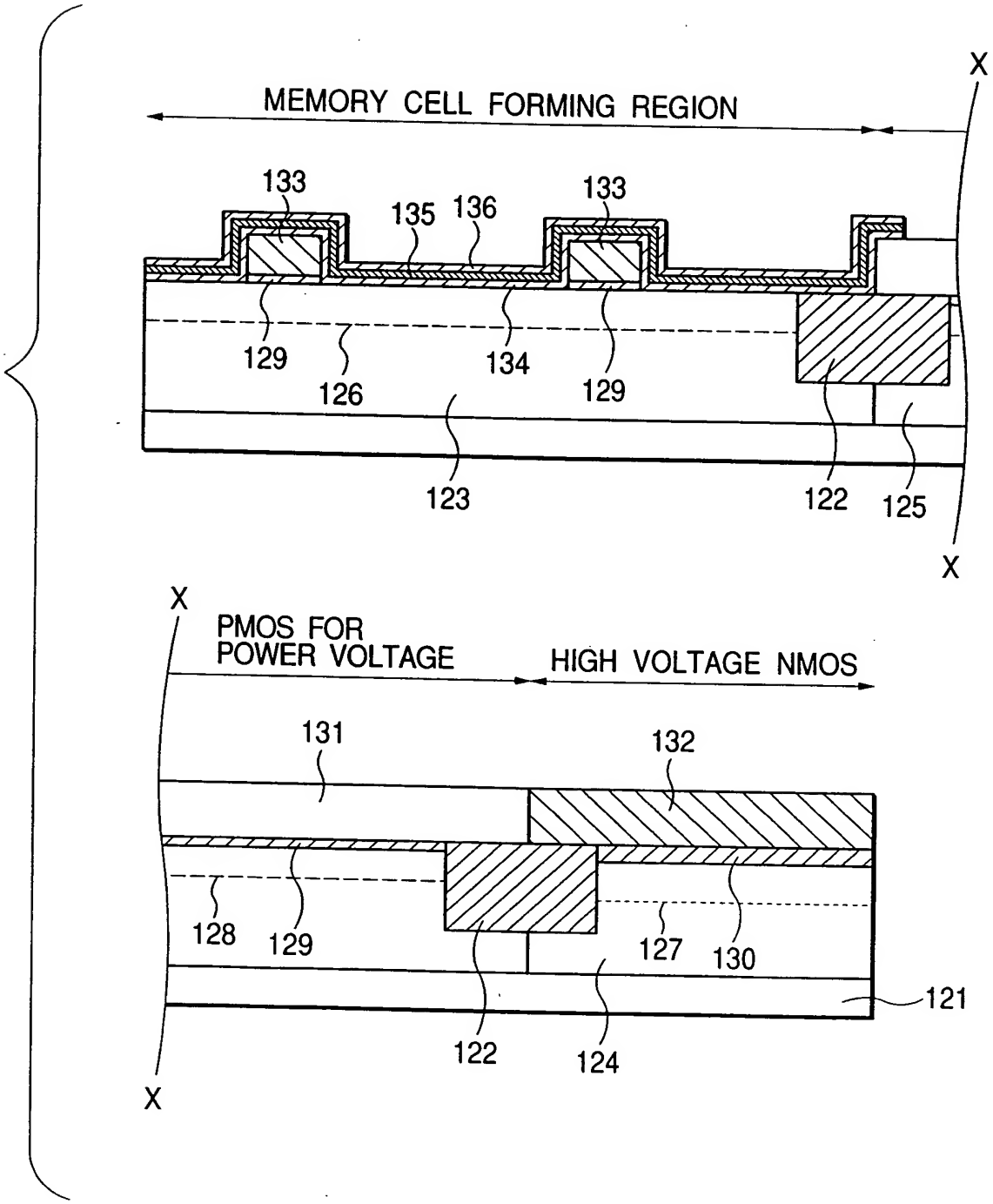

X
MEMORY CELL FORMING REGION
133
135
136
133
129
126
134
129
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
131
132
128
129
127
130
121
122
124
X

FIG. 54

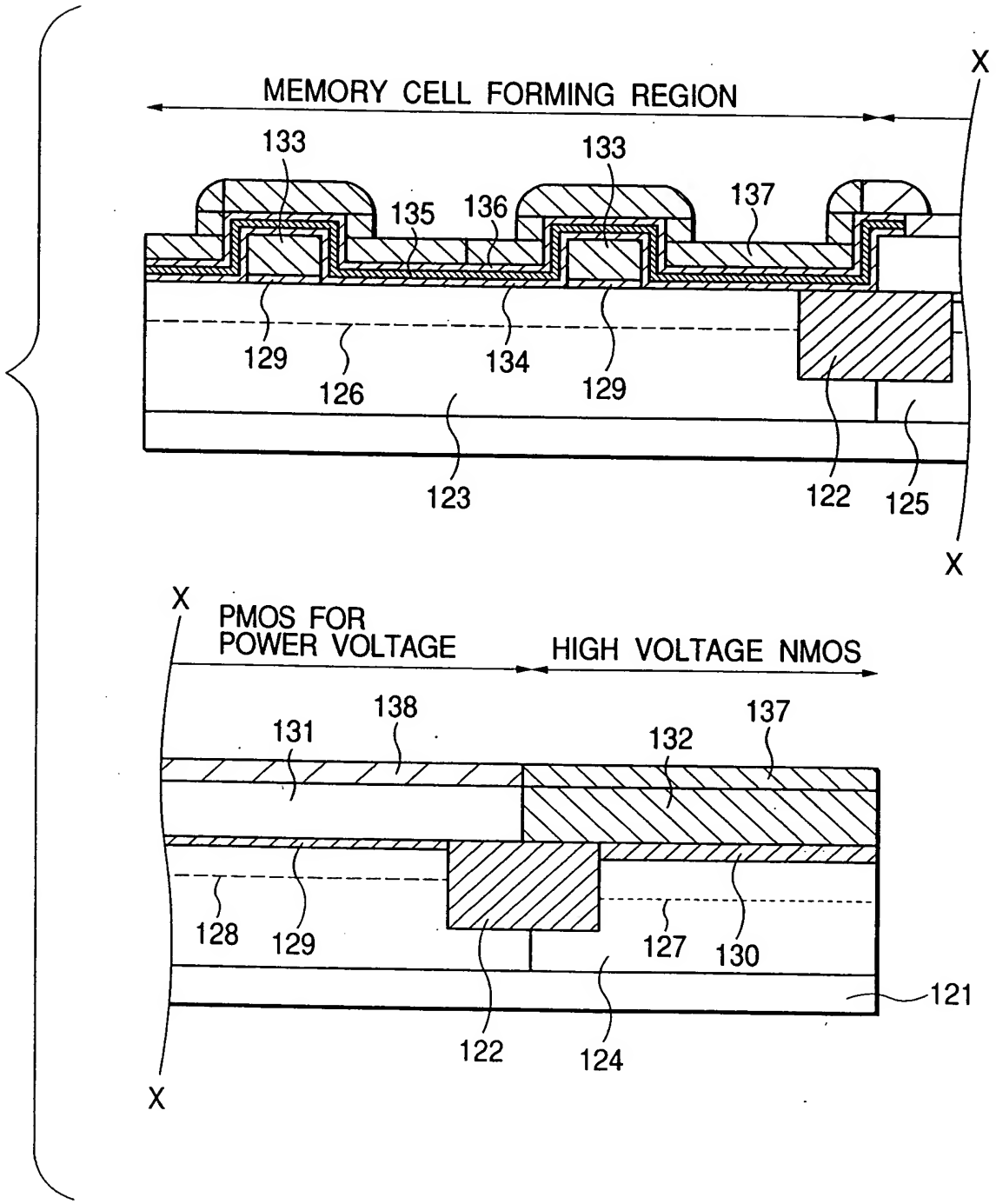

MEMORY CELL FORMING REGION
X
133
133
135
136
137
129
126
134
129
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
138
131
132
137
128
129
127
130
121
122
124
X

FIG. 55

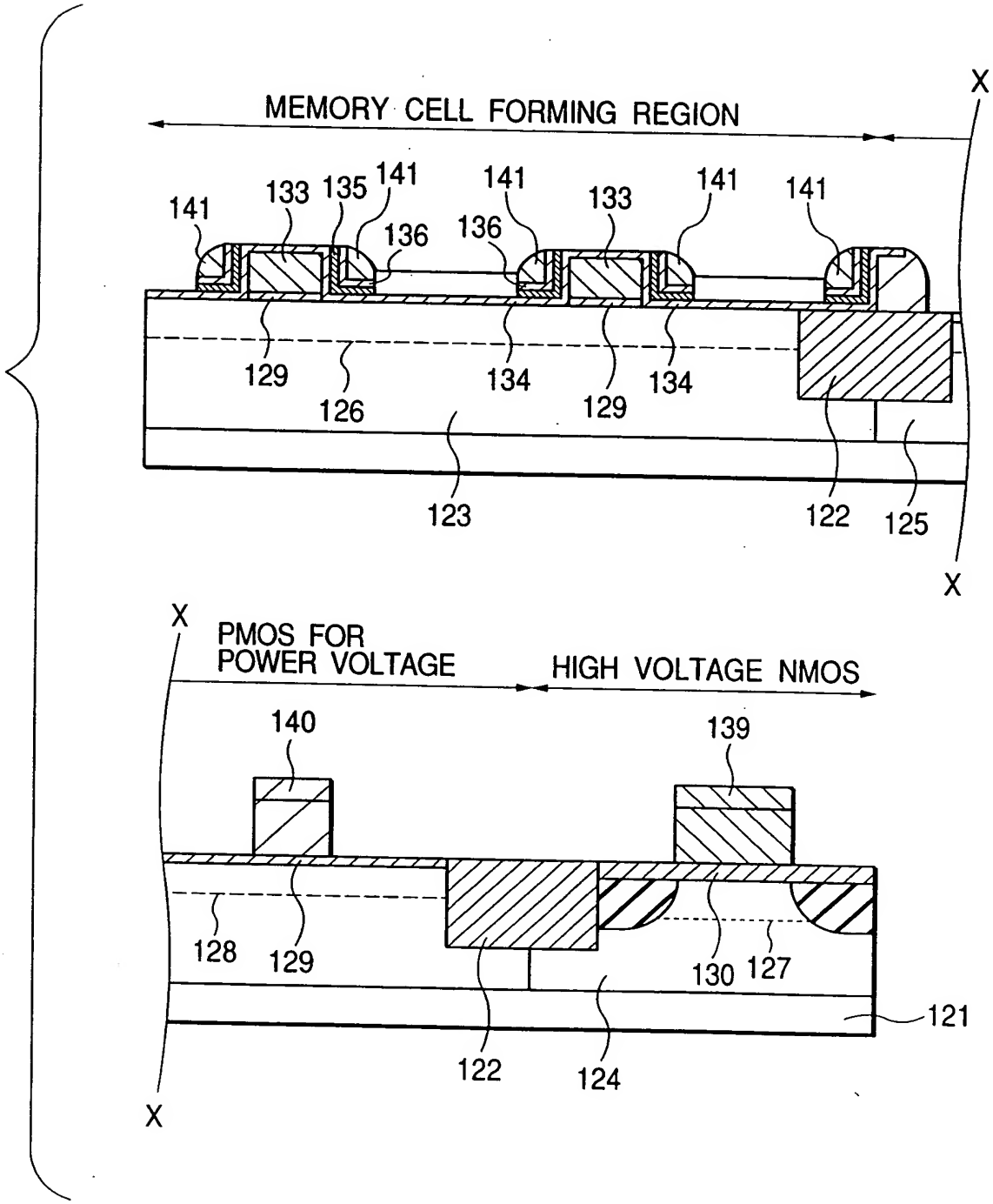

MEMORY CELL FORMING REGION
X
141
133
135
141
136
141
136
133
141
141
129
126
134
129
134
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
140
139
128
129
130
127
121
122
124
X

FIG. 56

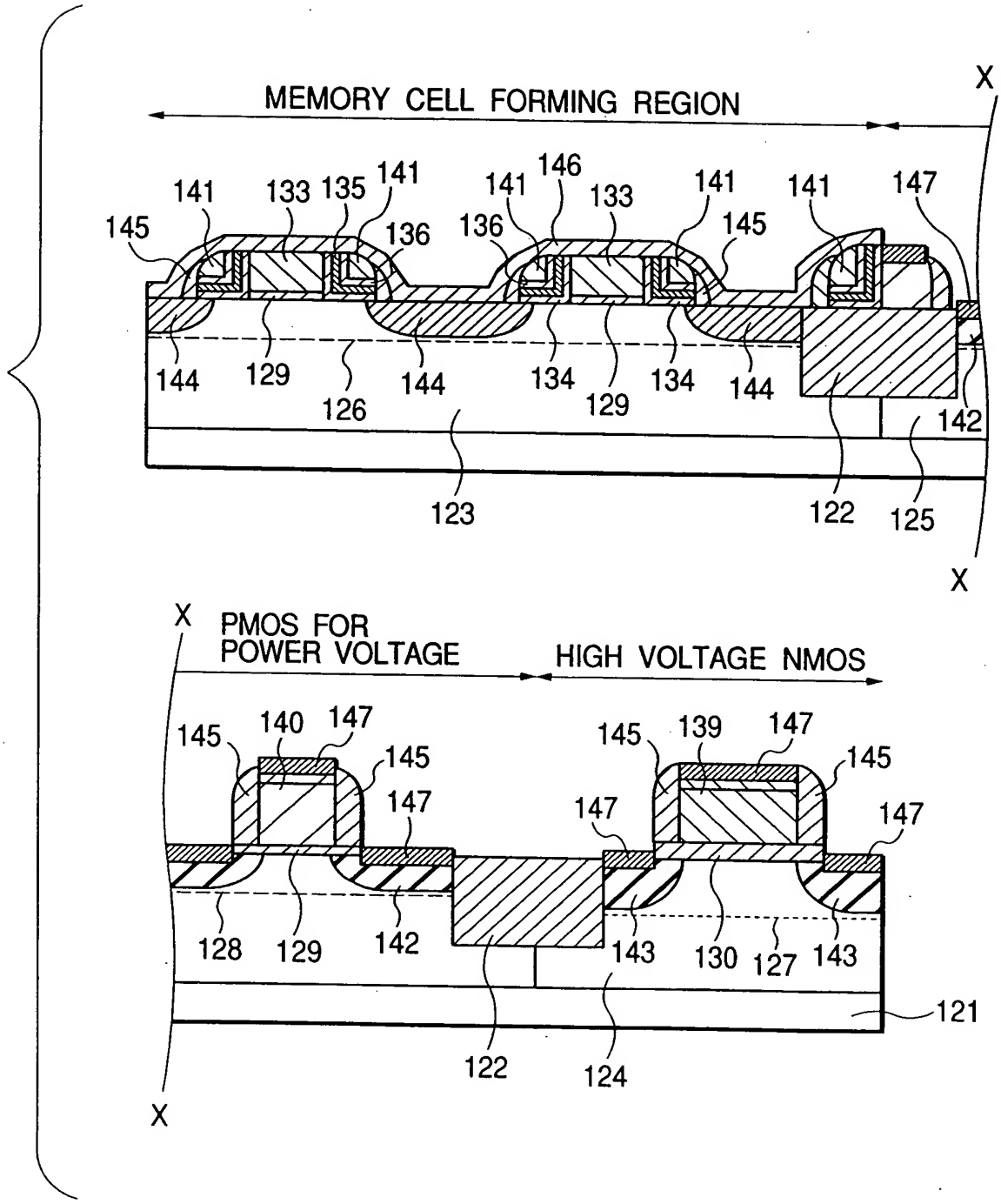

MEMORY CELL FORMING REGION
X
141
133
135
141
141
146
133
141
141
147
145
136
136
145
144
129
126
144
134
129
134
144
142
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
145
140
147
145
147
145
139
147
145
147
147
147
128
129
142
143
130
127
143
121
122
124
X

FIG. 57

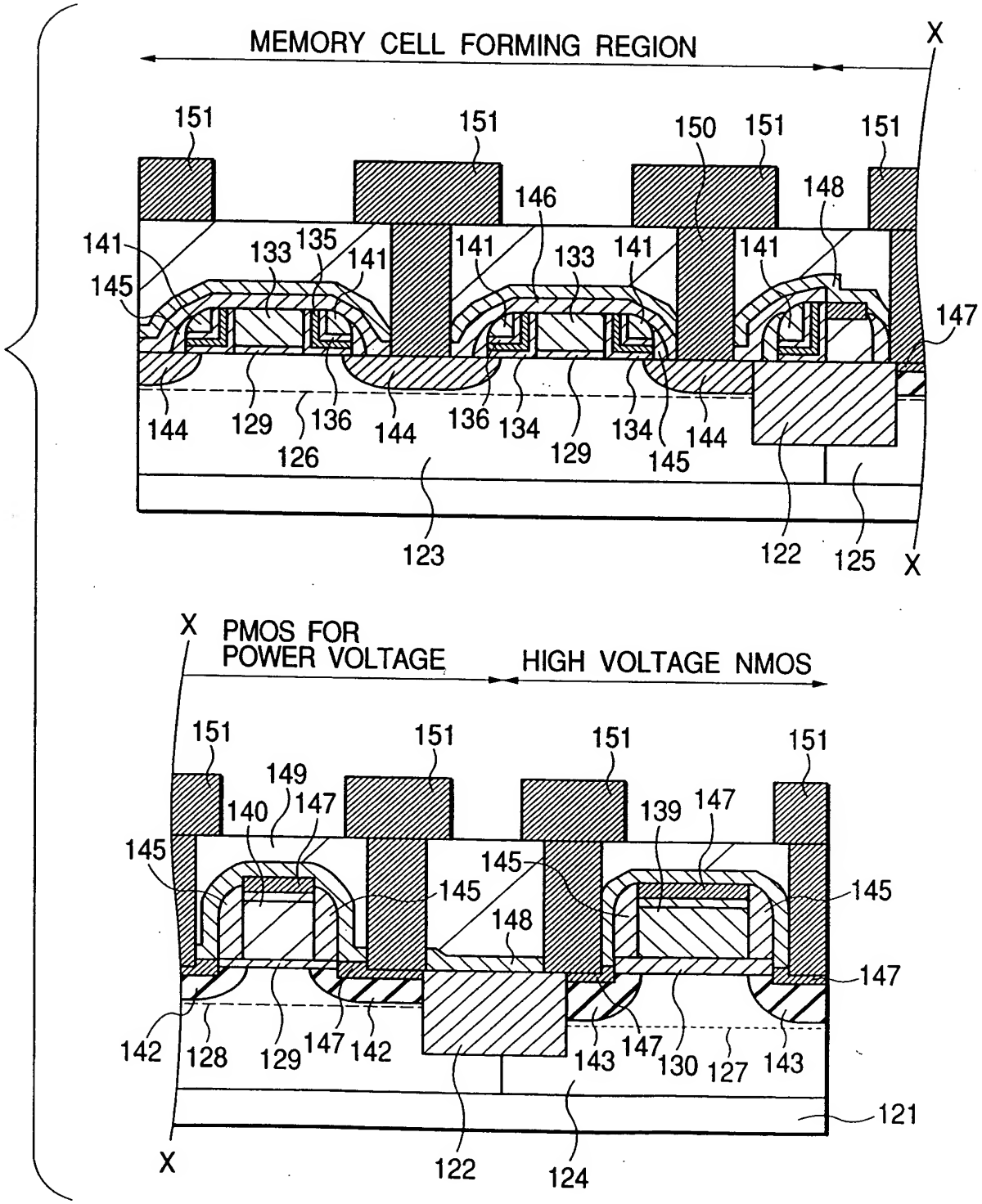

MEMORY CELL FORMING REGION
X
151
151
150
151
151
146
148
141
133
135
141
141
133
141
141
145
147
144
129
136
144
136
134
129
134
144
145
126
123
122
125
X
X
PMOS FOR
POWER VOLTAGE
HIGH VOLTAGE NMOS
151
151
151
151
149
140
147
139
147
145
145
145
145
148
147
142
128
129
147
142
143
147
130
127
143
121
X
122
124

FIG. 58

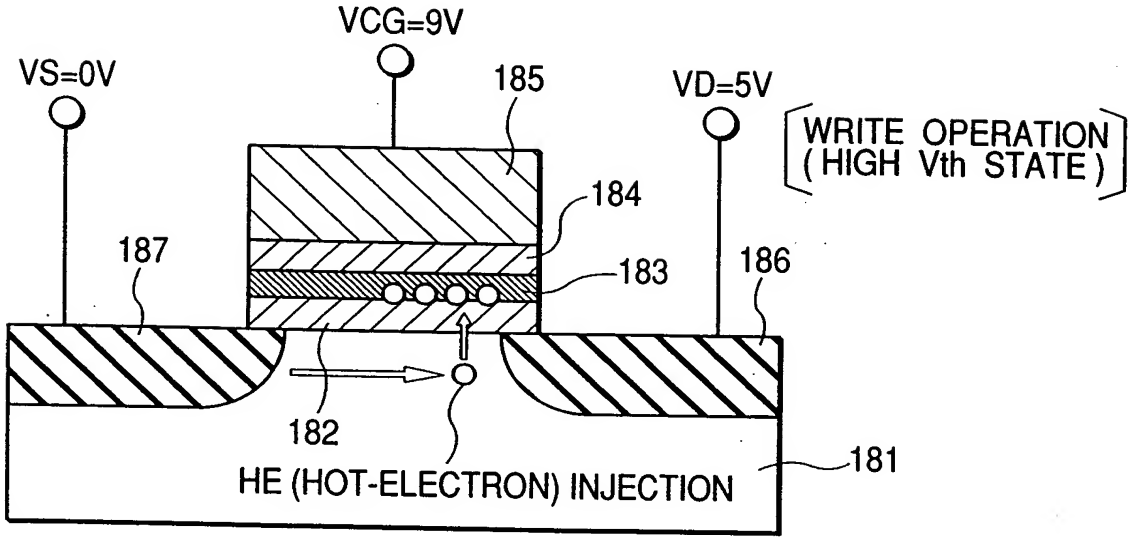

VCG=9V
VS=0V
185
VD=5V
WRITE OPERATION
(HIGH Vth STATE)
184
187
183
186
182
181
HE (HOT-ELECTRON) INJECTION

FIG. 59

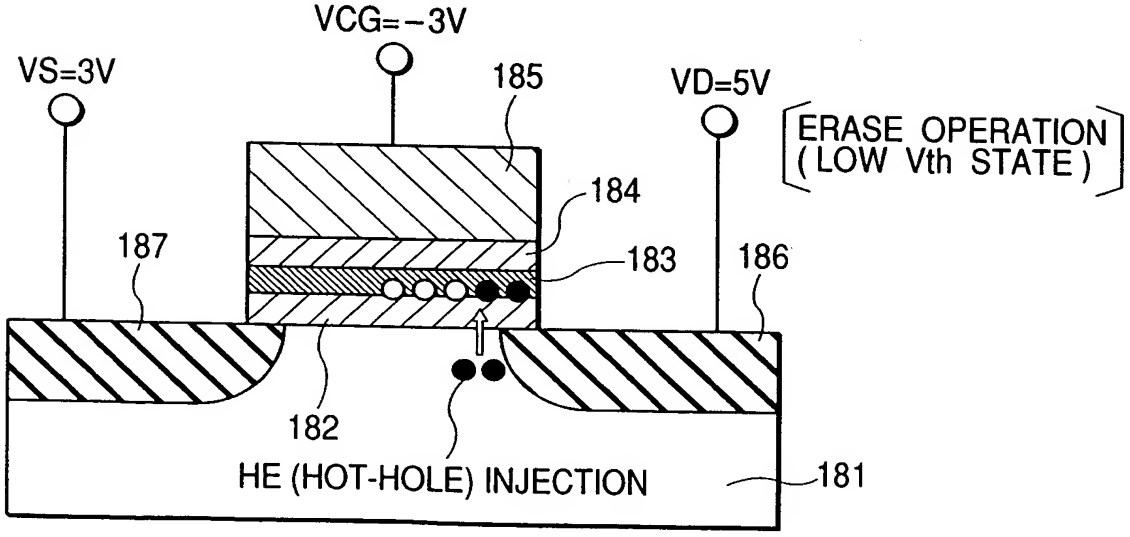

VCG=−3V
VS=3V
185
VD=5V
ERASE OPERATION
(LOW Vth STATE)
184
187
183
186
182
181
HE (HOT-HOLE) INJECTION

FIG. 60

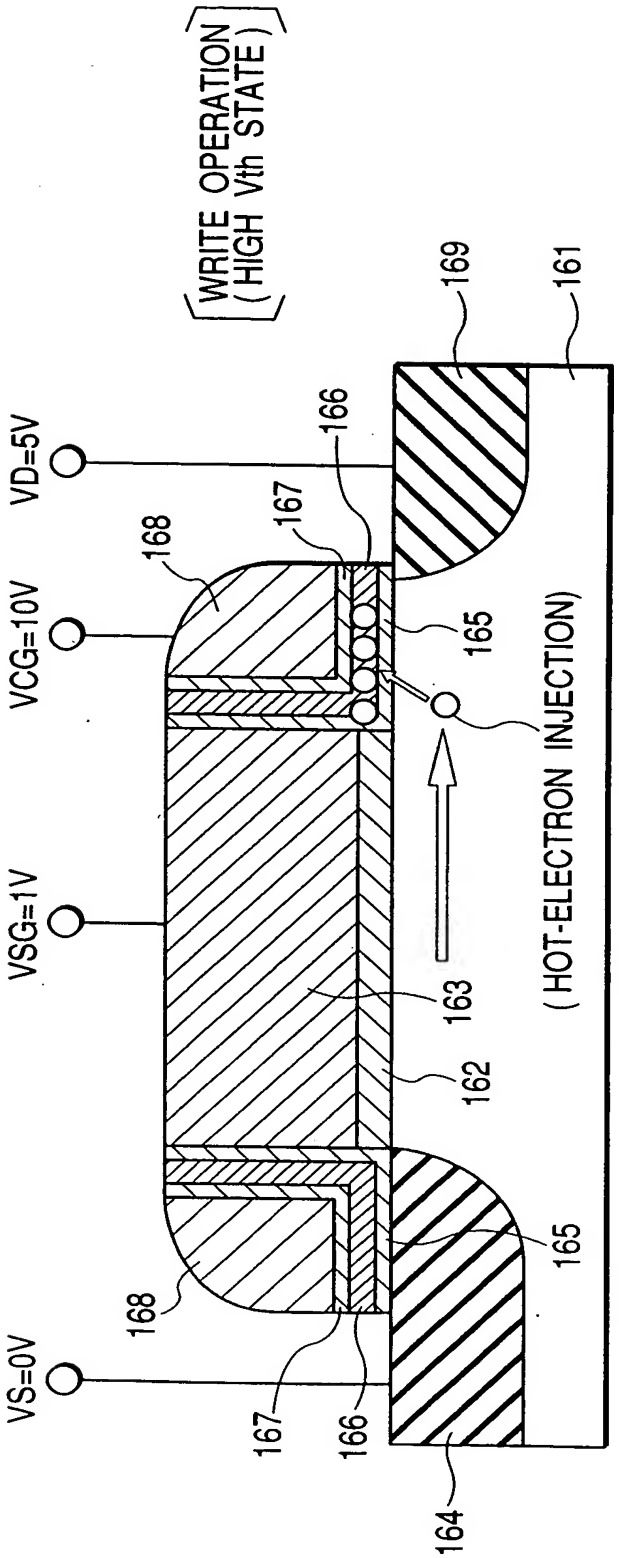

WRITE OPERATION
(HIGH Vth STATE)
VD=5V
VCG=10V
VSG=1V
VS=0V
(HOT-ELECTRON INJECTION)
161
162
163
164
165
166
167
168
169

FIG. 61

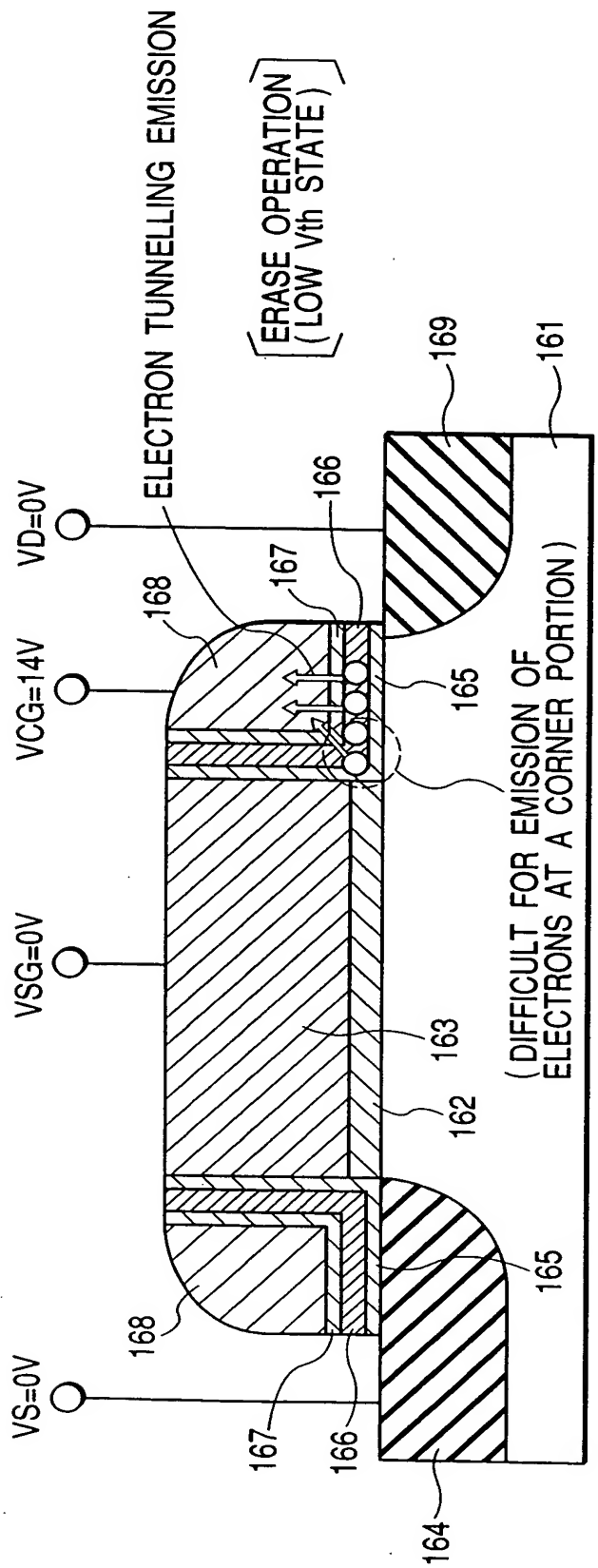

ELECTRON TUNNELLING EMISSION
[ERASE OPERATION (LOW Vth STATE)]
VD=0V
VCG=14V
VSG=0V
VS=0V
168
167
166
165
163
162
169
161
164
(DIFFICULT FOR EMISSION OF ELECTRONS AT A CORNER PORTION)

FIG. 62

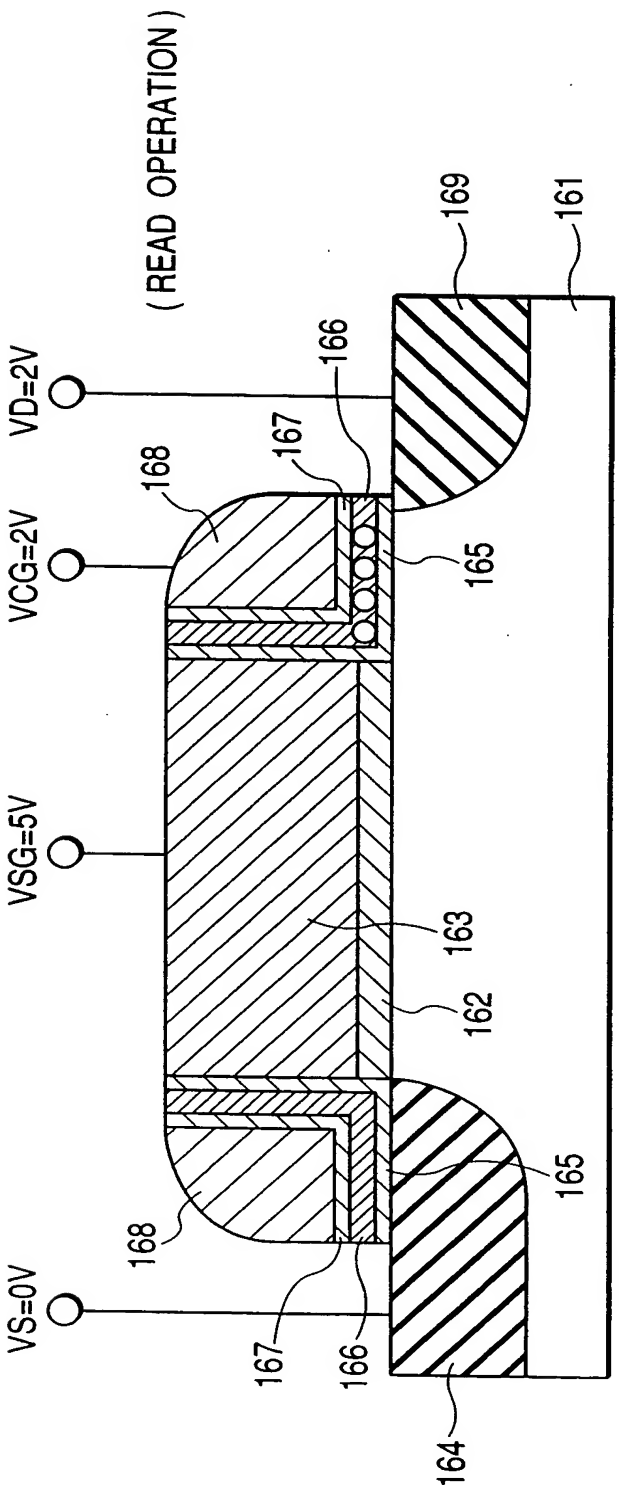

(READ OPERATION)
VD=2V
VCG=2V
VSG=5V
VS=0V
169
161
166
167
168
165
163
162
164

FIG. 63

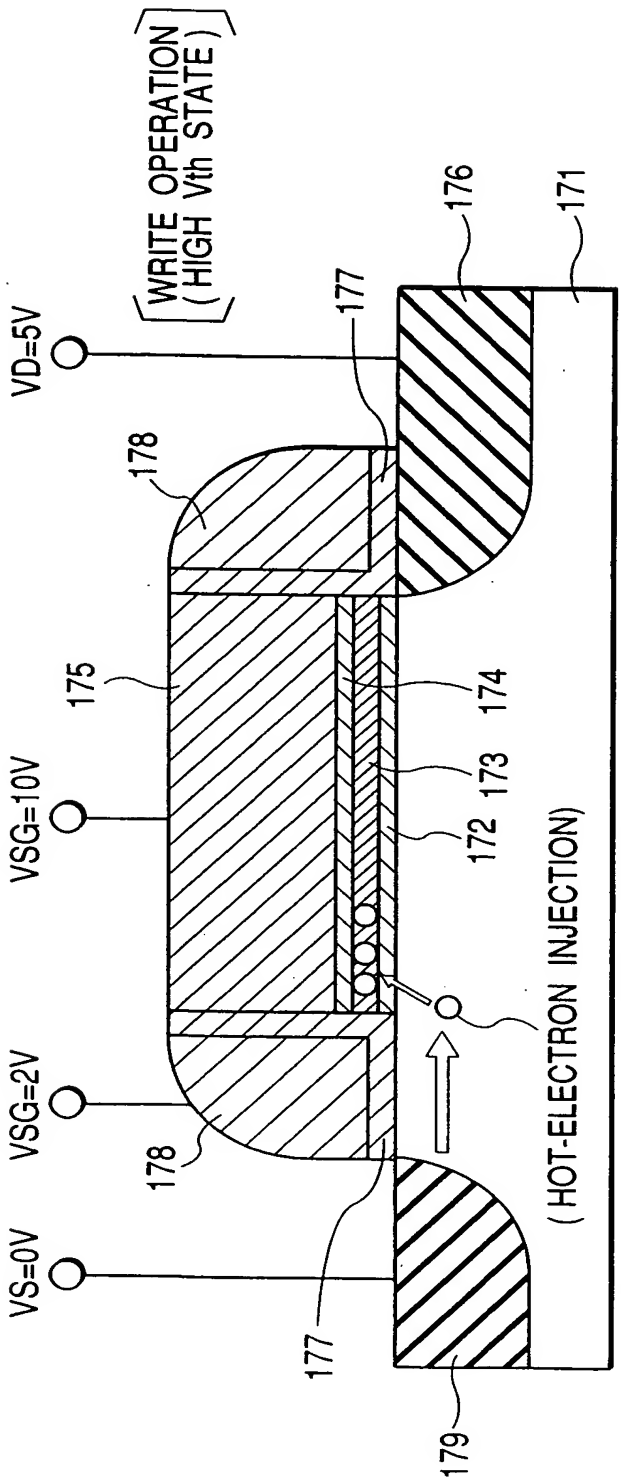

WRITE OPERATION
(HIGH Vth STATE)
VD=5V
VSG=10V
VSG=2V
VS=0V
176
171
177
178
175
174
173
172
179
(HOT-ELECTRON INJECTION)

FIG. 64

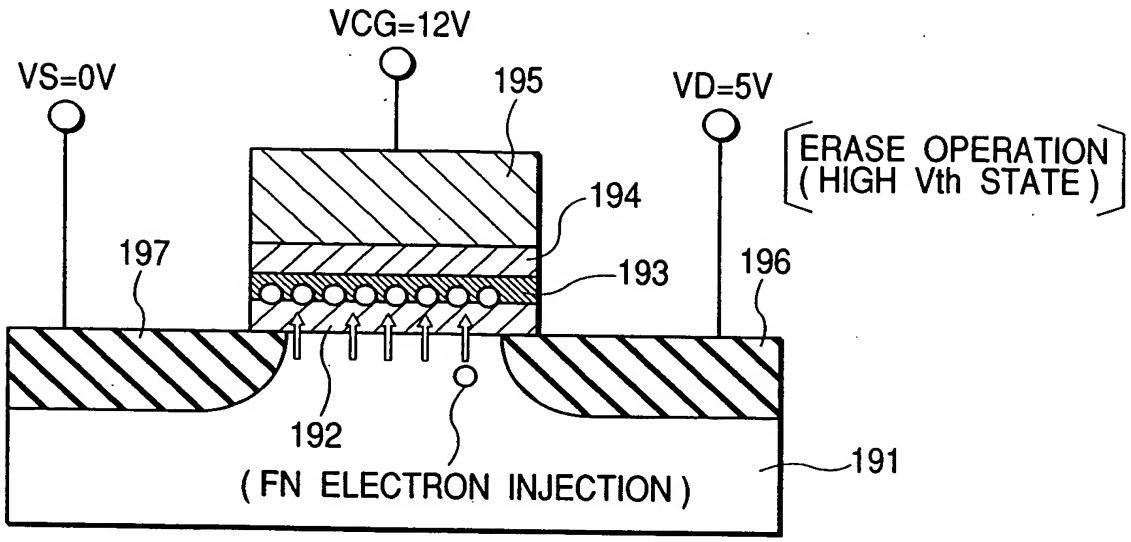
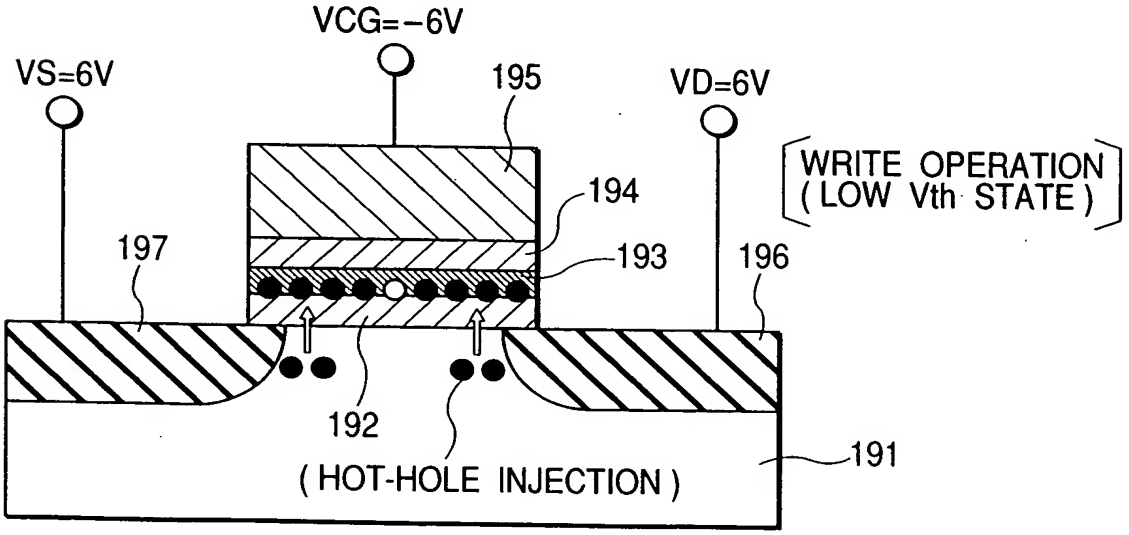

VCG=12V
VS=0V
195
VD=5V
ERASE OPERATION
(HIGH Vth STATE)
194
197
193
196
192
191
(FN ELECTRON INJECTION)

FIG. 65


VCG=−6V
VS=6V
195
VD=6V
WRITE OPERATION
(LOW Vth STATE)
194
197
193
196
192
191
(HOT-HOLE INJECTION)